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TWENTY-NINTH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
University Park, Pennsylvania

1965

FOR ADMINISTRATIVE USE ONLY

1965

Twenty-ninth Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
University Park, Pennsylvania
Forage and Range Research Branch
Crops Research Division,

Northeast Branch
Soil and Water Conservation Research Division,
and
Grain and Forage Insects Research Branch
Entomology Research Division
of the
Agricultural Research Service
U. S. Department of Agriculture

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - -

Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

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THE LABORATORY STAFF

J. T. Sullivan	Official in Charge
Lois L. Smith	Administrative Assistant
Amina M. Birkenmayer	Typist

Research Staff

J. H. Graham	Plant Pathology
C. F. Gross	Soil Science
R. R. Hill, Jr.	Alfalfa Genetics
A. W. Hovin	Grass Genetics and Cytogenetics
R. C. Newton	Entomology
R. R. Robinson	Soil Science
V. G. Sprague	Physiology and Microclimatology
J. T. Sullivan	Plant Chemistry
P. R. Bono	Technician, Plant Chemistry
K. E. Zeiders	Technician, Plant Pathology

Collaborators

R. B. Alderfer, New Jersey	W. F. Millier, New York
C. S. Brown, Maine	W. H. Mitchell, Delaware
G. L. Byers, New Hampshire	G. G. Pohlman, West Virginia
R. W. Cleveland, Pennsylvania	A. L. Steinhauer, Maryland
W. G. Colby, Massachusetts	D. D. Wolf, Connecticut
B. W. Henderson, Jr., Rhode Island	G. M. Wood, Vermont

H. R. Fortmann, Penna. - Representative of Northeastern Directors

* * * * *

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INTRODUCTION

This report, the twenty-ninth of the series, is intended for the use of personnel engaged in forage research in the Northeastern States. Included are reports of research at the U. S. Regional Pasture Research Laboratory, at state experiment stations of the Northeastern Region, and from the Forage and Range Research Branch at Beltsville.

There were some changes in personnel at the Laboratory during the past year. A. W. Hovin, Geneticist since 1958, left in August, 1965, and assumed the position of Research Leader, Grass and Turf Investigations at Beltsville. P. R. Bono, Technician, Plant Chemistry, resigned in November, 1965, to take a nongovernment position. Early in 1966, J. H. Graham, Plant Pathologist since 1950, left to assume the duties of Assistant Branch Chief, Vegetables and Ornamental Research Branch, Beltsville. D. E. McCloud, Research Leader, Humid Pasture and Range Investigations at Beltsville, who had supervised some of the research at the Laboratory, resigned in August, 1965, to become head of the Agronomy Department at the University of Florida. Early in 1966, G. E. Carlson, a former member of the Laboratory staff, was appointed to the position vacated by Dr. McCloud.

Members of the Laboratory staff have been active at scientific meetings. J. H. Graham attended the annual meetings of the American Phytopathological Society at Miami. R. R. Hill, Jr. and R. R. Robinson attended the annual meetings of the American Society of Agronomy at Columbus. J. H. Graham, R. R. Hill, Jr., R. C. Newton, and K. E. Zeiders attended and presented two papers at the Eastern Alfalfa Conference at Raleigh. Three of the staff are members of Northeastern Regional Technical Committees.

A major addition to the facilities of the Laboratory during the year was a growth chamber, bringing to seven the number of such chambers in which plants may be grown under controlled conditions of light, temperature, and, in some cases, humidity. Two greenhouse rooms were improved by the addition of ventilating equipment designed to lower summer temperatures and allow year round use.

RESEARCH AT THE PASTURE LABORATORY

GENETICS, PATHOLOGY, AND ENTOMOLOGY

Alfalfa

Recurrent Selection for Resistance to Common Leafspot in Alfalfa Populations MSA and MSB

History and results of 3 cycles of selection for resistance to common leafspot (caused by Pseudopeziza medicaginis) were given in previous Annual Reports (1964, p. 3). The 2 pools of alfalfa germ plasm were released to alfalfa breeders in 1965. Both pools were significantly more resistant to common leafspot than DuPuits, the most resistant check variety. Prior to the leafspot selection program, the material had undergone several cycles of selection for resistance to rust (caused by Uromyces striatus) and potato leafhopper yellowing (caused by Empoasca fabae) at Raleigh, N. C. and Beltsville, Md. The release was in cooperation with the North Carolina Agricultural Experiment Station.

Polycrosses of Disease Resistant Alfalfa Clones

History and development of clones resistant to several foliar pathogens were given in previous Annual Reports (see 1964, p. 3). Second-harvest-year data from polycross progenies of 65 of these clones were obtained in Pennsylvania, Minnesota, and Nebraska. Epiphytotics of specific pathogens have not developed at any location.

Screening for Insect Resistance

A procedure for screening alfalfa populations for resistance to spittlebug during the winter was given in the 1964 Annual Report. Work on procedures for screening for resistance to the potato leafhopper indicated that the number of wilted trifoliolates per plant and plant growth in the presence of leafhoppers may be satisfactory criteria for resistance. More work on this idea is needed, however. Damage caused by alfalfa weevil larvae can be easily obtained by sweeping trash from alfalfa fields in early spring and spreading it on flats containing seedlings. A program attempting to improve resistance to these insect pests in 2 wilt-resistant strains from Beltsville, Md. (MSA-W-4 and MSB-W-4) was initiated.

Twenty plants of 407 alfalfa introductions were transplanted to a field near State College, Pa. in August, 1964. Weevil damage was not great enough to permit reliable scoring in the spring of 1965. Adult numbers

were higher in the fall of 1965 than in 1964, and the damage is expected to be greater in the spring of 1966.

The damage caused by several of the lesser known species of insects (Adelpherois lineolatus, Lygus lineolaris, Philaenus spumarius, Athysanus spp.) was investigated. All species caused significant damage, but the relationship between field- and greenhouse-damage is unknown. This work will be continued if the insect species are present during the summer of 1966.

Comparison of Different Cycles of Phenotypic Selection in MSA and MSB Alfalfa

Several cycles of phenotypic recurrent selection for resistance to several pathogens have been conducted (base population = 7 cycles of selection for resistance to leaf rust and potato leafhopper yellowing in North Carolina, base + 3 cycles for leafhopper resistance in Maryland, base + 3 cycles for resistance to spotted alfalfa aphid in California and Arizona, base + 3 cycles of selection for resistance to common leafspot in Pennsylvania, and base + 3 cycles for leafhopper resistance + 3 cycles for rust resistance in Maryland). Remnant seed from each of these selection programs was used to establish tests at Clayton, N. C., Beltsville, Md., and State College, Pa. Data will be recorded to determine if characters for which selection was not practiced shifted.

Selections from Connecticut with Resistance to Bacterial Wilt and Crown and Root Rots

History of the Connecticut clones and experiments in progress was given in previous Annual Reports (see 1964, p. 3). Survival notes were taken on a 1962 planting near State College, Pa. (14-plant rows); progenies of the Connecticut clones averaged 11.4 plants per row, DuPuits - all dead, Narragansett - 3.0, and Vernal - 8.5. D. D. Wolf at Storrs, Conn. is studying agronomic characters of single crosses between some of the Connecticut clones.

Ten of the better-looking clones were selected from the planting near State College, and will be used as parents of synthetics. Ten clones were selected from a planting of progenies of 2 wilt-resistant DuPuits clones near Easton, Pa. for a similar set of synthetics. The synthetics will be compared for wilt resistance and other characters.

Comparison of 4 Methods of Selection in Alfalfa

The first cycle of selection in an experiment to determine the relative effectiveness of tandem, independent culling levels, sum of ranks, and index methods of selection for resistance to 4 alfalfa pathogens (Uromyces striatus, Pseudopeziza medicaginis, Corynebacterium insidiosum, and Leptosphaerulina briosiana) and for recovery after cutting was initiated

in the fall of 1965. The base population for this program was obtained by intercrossing equal numbers of plants from DuPuits and Vernal.

Inbreeding in Alfalfa

Previous work and objectives of this project were given in the 1964 Annual Report (p. 4). Fifty S_1 lines were established in the fall of 1965 and S_2 seed obtained during the winter. About 30 lines in each pool (MSA-W-4 and MSB-W-4, from Beltsville, Md.) set seed.

Designs to Estimate Effects of Clone Substitution in Alfalfa Synthetics

Several designs that will permit estimation of variance components due to effects of clone substitution in populations of 4-clone alfalfa synthetics were examined. Designs using 8 to 180 clones and requiring 64 to 126 synthetics were found. Most of the designs were modifications of the ideas used in 4-factor factorial experiments.

Preferential Chromosome Pairing in Autotetraploids

The effects of preferential chromosome pairing in the duplex individuals of a theoretical autotetraploid population were investigated. Homogenic pairing (similar alleles pair) was assumed to occur with probability $(1-2\theta)$ and heterogenic pairing (dissimilar alleles pair) with probability 2θ . $\theta = 1/3$ corresponds to random chromosome segregation. Under random mating, (a) at least one type of gamete is eliminated when $\theta = 0$, (b) the level of homozygosity increases as θ increases, (c) the level of homozygosity is never as great as with completely random chromatid segregation, and (d) the effects of preferential pairing are not very great when gene frequency is near 0 or 1. With self-fertilization, (a) homozygosity will never be reached if $\theta = 0$ and the original population is heterozygous, (b) the rate of approach to homozygosity increases as θ increases, (c) the final homozygous state is the same for any nonzero value of θ , and (d) the approach to homozygosity is more rapid for random chromatid segregation than with any value of θ .

Effect of Potassium Levels on Susceptibility of Alfalfa to Fusarium oxysporum medicaginis (Fusarium wilt)

An experiment was conducted in the greenhouse to study the effects of Fusarium oxysporum medicaginis on a resistant selection (MSA), a selection intermediate in reaction (Conn. C2), and a susceptible variety (DuPuits) of alfalfa grown in sand at high and low levels of Na and K. Plant growth was reduced at the low level of K, but tissue analysis indicated that K was not deficient. Growth was not affected by Na levels. The severity of

Fusarium wilt was not affected by levels of either element. Plant mortality was high. There was no relationship between resistance and tissue analysis of Ca, Mg, Mn, Cu, Zn, or Al.

Isolations from Diseased Alfalfa

A previously unreported leaf disease of alfalfa (and other legumes) caused by Myrothecium rosidium is being studied. Preliminary experiments indicate an injury is required for initial infection.

Red Clover

Chemical Compounds Associated with Internal Breakdown (IB) of Red Clover

An attempt was made to identify some of the chemical compounds associated with IB of red clover. No significant differences were found in the amino acids in healthy and diseased pith tissue. Differences in the inorganic elements present in whole crowns with and without IB were not great. A third approach used thin-layer and paper chromatography as means of separating and characterizing fluorescent compounds in IB tissue. Several highly fluorescent spots were obtained from IB tissue that were absent in healthy tissue. The compounds were tentatively identified as belonging to the family of phenols. There appeared to be little or no coumestrol in the IB tissue.

Persistence of Selections of Red Clover Resistant to Internal Breakdown (IB)

Field plots of red clover were established at the U. S. Regional Pasture Research Laboratory in the spring of 1964 to compare the persistence of selections resistant to the physiogenic disease, internal breakdown (IB) with selections and varieties susceptible to IB. During the summer of 1965 a severe infestation of root borers accompanied a notable reduction in stand. Ground cover of Pennscott red clover was reduced 37% while the better selections were reduced 20%. The stands of strains selected earlier for general persistence were reduced approximately 15%. Plants were dug from each plot for root examination. Roots varied little in size, but the IB-resistant selection had 50% less IB than nonselected plants. Root borer damage and external taproot rot were severe on plants in all plots. A relatively large population of the northern root knot nematode was observed in this area for the first time. Pennscott and the IB-resistant selections (originally selected from Pennscott) were resistant to the nematode. Lakeland, Kenland and the other selections were susceptible.

Effects of Insecticide and Fungicide Drenches on Persistence of Red Clover in Caged and Noncaged Plots

Field plots of red clover were established at the U. S. Regional Pasture Laboratory in 1964 to study the effects of insects and soil microorganisms on persistence. Main treatments included caged and noncaged plots with 4 subtreatments: application of soil insecticides, fungicide drench, both pesticides, and no spray (check). Results as of October, 1965 indicated that the fungicide (Polycide) had no effect on yield or number of plants dying. Plants in plots receiving insecticides (Heptachlor, Lindane) yielded almost twice as much as those in nonsprayed plots. Also fewer plants died and fewer developed virus. Plants under cages were more vigorous and healthier than noncaged plants.

Red Clover Growth Habit Studies

The growth habit of red clover was studied to determine its relationship to lack of persistence. Normally, the primary meristem remains vegetative and produces trifoliolate leaves throughout the life of the plant. Under certain conditions (e.g. long day) low percentages of plants produced terminal flowers, thus ending the production of trifoliolates. Often these plants died if they were clipped regularly. Environmental factors may also alter the site of the first secondary branch. Under short photoperiods and at low temperatures the first secondary branch arose at a lower leaf axil than under other environments. Buds below the first secondary branch usually did not develop normally. The above factors may be related to the short-lived perenniality of red clover.

Bromegrass

Selections with Leaf Disease Resistance

Two experimental synthetics, the 6-clone Syn D and the 7-clone Syn E, were constituted in 1964. Syn 1 seed was produced in sufficient quantity in the greenhouse in 1964/65 to establish seedlings from each parent. Equal numbers of Syn 1 seedlings within each synthetic were used to establish isolated plantings for production of Syn 2 seed in 1966 and 1967. The parent clones were also planted in the field to obtain additional Syn 1 seed. Due to drought only 1 forage harvest was made of the progeny test in 1965. None of the entries exceeded the yield of Saratoga but the quality of the forage may have been higher because of less leaf disease.

Orchardgrass

Nonheading Orchardgrass

(In cooperation with G. M. Wood, University of Vermont)

The Syn 1 generation of three 4-clone synthetics was compared with 'Pennlate' in solid-seeded field plots established in 1964 for evaluation of panicle and hay production. Additional varieties were included in the Vermont test. In June 1965, Pennlate, Syn A, Syn B, and Syn C produced respectively: 12.6, 13.1, 4.1, and 1.7 panicles per square foot in Pennsylvania and 37.2, 4.3, 1.8, and 0.6 in Vermont. Dry matter yield of Syn C for both locations was lower than that of Pennlate, which outyielded other entries in Vermont.

Male-Sterile Orchardgrass

Several heterozygous male-fertile F_1 clones selected in 1964 were intercrossed and produced seed in the greenhouse in 1964/65. Sufficient seed was obtained to establish at least 250 seedlings from reciprocals of 6 crosses. It is hoped that the material will supply the necessary data during anthesis in 1966 to demonstrate the mode of inheritance of male-sterility in orchardgrass.

Ryegrass-Fescue Intergeneric Hybrids

Several ryegrass-fescue clones with 28 chromosomes were crossed to tall fescue to incorporate diversified germ plasm into tall fescue. Seed set after open pollination of the tetraploid clones was variable but generally high for the annual ryegrass x meadow fescue clones. These clones gave high seed set when crossed to tall fescue. Future work will include chromosome determinations of progenies in an effort to stabilize populations at certain ploidy levels. Several 42-chromosome hybrid derivatives have been combined into 4-clone synthetics based on topcross performance at Hershey, Pa., in 1964 and on grazing trials at Lexington, Ky. Syn 1 seed was obtained and isolated plantings were established in the field to obtain Syn 2 seed in 1966 and 1967. The parent clones were also established in the field to obtain additional Syn 1 seed. A forage yield trial gave inconclusive data due to the severe drought in 1965.

Cytogenetics of Ryegrass-Fescue Material from Kentucky

Chromosomes counted for 300 selected plants ranged from 28 to 56 as the somatic numbers. The additional objective was to compare progenies from reciprocals of backcrosses to tall fescue of annual ryegrass x tall fescue amphiploids. There appeared to be fewer micronuclei in material having tall fescue cytoplasm as compared to the reciprocal. Because of chromosome clumping, pairing behavior was difficult to analyze.

BIOCHEMISTRY, PHYSIOLOGY, AND SOILS

Carbohydrate Studies on Forages

Studies on hemicellulose and cellulose in forage plants are being continued (see 1964 Annual Report, p. 10), with the purpose of obtaining information relative to nutritive value or voluntary intake. Materials for study were obtained from state stations, particularly New Jersey and West Virginia. In timothy, the percentage of hemicellulose increased with maturity up to May 19 (in New Jersey) and thereafter remained constant. The hemicellulose: cellulose ratio also reached a maximum on that date. In alfalfa and Kentucky bluegrass, the percentage of hemicellulose was negatively correlated with digestibility of dry matter but not with relative intake. In timothy, orchardgrass, bromegrass, and sudangrass, the digestion coefficient of cellulose was positively correlated with intake.

The Lignin Content of Forages

The apparent lignin content of forages is increased if the forage is dried with heat. At least 2 substances were found to contribute to this increase: one was in the lipid fraction; another, less important, was in the protein.

In the analysis of the forage for lignin, protein is removed by digestion with pepsin. The incorporation of a wetting agent, or detergent, viz., hexadecyltrimethylammonium bromide, into the pepsin did not inhibit the activity of the pepsin, made unnecessary the digestion at an elevated temperature, and improved the uniformity of the lignin analysis.

In samples from the West Virginia station, lignin was negatively correlated with the digestibility of dry matter in timothy, orchardgrass, bromegrass, and sudangrass. It was negatively correlated with intake in orchardgrass and sudangrass only.

Climate at State College, Pa.

The Northeastern Region was dry during 1965. At State College, the total precipitation was 28.13 inches, or 10.57 inches below the 1931-1960 mean. Rainfall was limited particularly in April through July and in September, November, and December. Besides restricting plant growth, the drought lowered water levels of rivers and ponds, and in many wells.

The yearly mean temperature was near normal but monthly means varied. May, September, and December were above normal while January, March, and October were below normal. Temperatures at a height of 3 inches above a sod were 1° to 2° warmer than at 60 inches above a sod during the spring and summer. During the fall and winter the mean temperatures at the 2 heights were

about alike. The location nearer the ground was subject to great daily variation; its range was 1° to 2° greater in November through March, 4° to 5° greater in April, May, August, September, and October, and 8° greater in June and July at the 3-inch than at the 60-inch level (Table 1).

Soil temperatures were measured at 2- and 3-hour intervals at 6 levels between 2 and 20 inches below ground. The mean yearly temperatures were between 52.4° and 53.1° , irrespective of depth. The mean daily range for the whole year was greatest at the shallowest depth, 9.9° and least at the 20-inch depth, 0.7° . At the 2-inch depth the mean annual temperature was lowest in February, 30.5° , and highest in July, 76.5° . The mean daily range at 2 inches was least in January, 1.1° , and greatest in July, 21.1° . The mean daily range at 8 inches was 0.4° in January and 5.7° in July; at 20 inches, the figures were 0.4° and 0.8° .

Soil moisture was measured several times a week with gypsum blocks at the same 6 levels. Early in May moisture was near field capacity at all levels. Later in May it decreased at the 2-to 12-inch levels. By June this decrease was also found at the 16-to 20-inch depths and wilting points occurred nearer the surface. In July this decrease in moisture continued, resulting in less than 10% available moisture down to the 12-inch level. Rainfall in August increased soil moisture down to the 8-inch level, very slightly to 16 inches, but not below. There was further drying out in the early fall but a slight increase in moisture after late October.

The amount of radiant energy was highest in June and July with over 65% of possible radiation. Only 55% occurred during May, August, and October, and because of cloud cover only 33-35% in December and January. The wind in February, October, November, and December was about half that in June and July. Evaporation from atmometers was highest in July, slightly less in May and June, lower in August, and much less in September. At 3 inches above the sod the evaporation was only one-half to two-thirds that at the 60-inch height.

Effects of Environmental and Defoliation Treatments on the Morphological Development and Dry Matter Production of Red Clover

Pennscott red clover seedlings were grown 7-1/2 months at 2 greenhouse temperatures, 58° and 73° , under long- and short-day conditions, and with "severe," "lenient" and "no-cut" defoliation treatments. Dry weights of top growth indicated that, during the first 6 months' growth after seeding, more growth occurred under the warmer temperature and a 16-hour daylength than at the cooler temperature and a 12-hour daylength. During the next 1-1/2 months plants which previously had grown at the lower cool temperature and under the short days made greatest growth under the higher temperature and the long days.

Under all environmental conditions least total dry matter was produced under the "severe," more frequent cutting, during both the initial 6 months and the 1-1/2 months following.

Table 1. Monthly precipitation and air temperature °F at State College, Pa. 1965.

Month	Precipitation		Temperature	
	Liquid inches	Dep.* inches	Daily mean	Dep.* °F
January	3.09	+0.42	24.7	-4.0
February	2.04	-0.15	27.7	-1.6
March	4.57	+0.87	33.7	-2.9
April	2.26	-1.25	47.6	-1.1
May	2.28	-2.11	64.7	+4.8
June	1.50	-2.07	68.6	+0.4
July	1.17	-2.61	72.2	+0.1
August	3.89	+0.36	70.4	+0.2
September	1.51	-1.11	65.6	+2.7
October	3.23	+0.30	49.9	-2.7
November	1.70	-1.35	41.0	0
December	0.89	-1.87	35.7	+5.2
Yearly	28.13	-10.57	50.3	+0.2

* Departures from U.S.W.B. 30-year means (1931-1960).

The first branch developed usually near the third node at each of the temperatures but was often one node higher under long days and a node lower under short days.

The number of secondary branches formed during the first 6 months was largest under the warmer temperature and shorter daylength and the number was least under "severe" defoliation. At the end of the second period of growth of 1-1/2 months under a warm temperature and long days the numbers of new branches were similar irrespective of previous temperatures. Considering possible effects of the various daylength treatments, plants formerly growing under short days maintained a larger number of branches and those previously under long days had fewer branches. At the end of the 6-month period a comparison of defoliation treatments indicated that branching was less under "severe" than under "lenient," and still less under the "no-cut" treatment. At the end of the second growth period, fewer branches were found in the "severe" treatment than in the other two, which were alike.

Because branches are axillary and only one branch develops at a node on the primary axis, additional branching is dependent on the vegetative condition of the terminal bud. Long daylengths normally stimulate terminal buds to become reproductive and thus limit formation of additional leaves and vegetative branching. This condition has not been observed frequently on the primary stem. Because it may be a factor affecting continued growth of red clover, observations were made to determine any relationship to the several treatments used here. While within the various treatments in this trial reproductive terminal buds were more frequent in one group than in another, no significant relationships between treatments were found.

All plants were harvested after 7-1/2 months of growth and soil was washed from the taproots. Roots were cut horizontally just below the crown and their diameters measured. The upper portion of the root was also cut longitudinally down the center and observations recorded on the frequency and extent of internal breakdown (IB). Larger roots had developed under short days and smaller roots under long days. "Lenient" defoliation reduced root diameter slightly and the "severe" treatment reduced it more. Observations on frequency and volume of IB conditions within the roots indicated that IB occurred most frequently in plants grown under treatments which favored highest production. Thirty-eight percent of the plants under "no-cut" showed IB, 27% under "lenient" cut and only 11% of the plants showed IB when given the "severe" treatment. Least IB occurred in plants grown under environment and management conditions which limited their growth.

Recovery Growth Under Fluorescent Lamps

Previous trials indicated that growth varied with the spectral distribution of radiation when intensities were expressed as footcandles. Poor growth occurred at the higher footcandle intensities provided by cool-white lamps near the blue end of the spectrum; good growth occurred when radiation covered a broader spectral band extending into the yellow as provided by warm-white lamps; and best growth occurred under a combination of warm-white and experimental-red lamps. Recently a new lamp, Gro-lux, has been developed

with a phosphor that supplies a higher proportion of radiation near the red end of the spectrum in addition to that more commonly extending into the blue. Growth, determined as grams of dry top vegetation produced during different periods and also as amounts in darkness, was used to express relative amounts of energy accumulated within the plants which was available for initiation of new plant parts.

Twenty-five grass plants were evenly spaced 3 feet below banks of 18 fluorescent lamps above 4 growth chambers with temperatures between 75 and 80°F. Radiation energy supplied to all chambers was similar when expressed as gram calories/cm² measured with an Epply pyroheliometer, but varied appreciably when expressed as footcandles measured with a Weston meter. These intensities were warm-white 602 ft-c, Gro-lux 484 ft-c, cool-white plus experimental-red 448 ft-c, and warm-white plus experimental-red 387 ft-c.

In this trial cuttings from 3 clones of orchardgrass and 1 of meadow fescue were established in fertile soil and grown in the greenhouse for 3 months. Weights of dry top growth cut 1-1/2 inches above the soil were used to measure the uniformity of 3 replicates used in each treatment.

After periods of 7, 14, 21, 28 and 42 days 3 plants were taken from each chamber. After top growth was removed to obtain dry weights the pots were moved to darkness for growth to measure relative amounts of energy which had accumulated and was available for regrowth.

This biological measure indicated that during the first 14 days the energy which had accumulated in the greenhouse and expressed as grams of dry matter available to the plant for regrowth, was utilized to form new leaves. After 21 days small increases became evident but not until 42 days was the initial condition approached. At this time most top growth occurred on plants under warm-white plus experimental-red and cool-white plus experimental-red. Growth of plants under warm-white was only slightly less than that on plants under Gro-lux. Energy accumulations expressed as milligrams dry matter per tiller made in darkness were in similar order to the milligrams of green leaves produced after 7, 14, 21, 28 and 42 days.

The general color and vigor of the plants were good, even better than that of many plants growing in the greenhouse during November and December. The only apparent difference on plants under the 4 qualities of radiation was the slightly darker green of leaves under Gro-lux.

Relation of Temperature to Responses of Phosphorus Fertilization

Red clover seedlings were grown in controlled temperature chambers at 20° and 10°C. Rate of growth both of tops and roots was determined for several rates and placements of P fertilizer on a soil very low in available P. Samples are being analyzed for total P content.

Rate of growth was far more rapid at 20° than at 10°C. The differences in plant growth at the 2 temperatures increased with time, and yields after 7 weeks were about 10 times higher at the higher temperature. Similarly the increases in yield from P fertilization became progressively greater with time. Increases of nearly 40 fold were obtained.

For equal growth periods actual as well as percentage increases in yield from P fertilization generally were greater at 20° than at 10°C.

Responses of young seedlings to P fertilizer at comparable stages of growth, however, were similar for the 2 temperatures. Both the actual and the percentage increases in yield of young seedlings from P fertilization were the same in x days at 20° as in an average of 2.2 x days at 10°C. At later stages of seedling growth this relationship did not always hold.

Plant Competition Studies

Nutrient solution culture studies were conducted to evaluate the effects of established orchardgrass plants on growth of ladino clover seedlings where nutrients were adequately replenished and any possible grass root exudates allowed to accumulate. Competition for light was controlled by the use of plastic shields, in addition to keeping the clover to the south part of the pot.

Nutrient solutions of different concentrations, both changed and unchanged, were employed. In the solutions that were not changed, nitric acid was added as needed to maintain pH values, and potassium and calcium nitrates were supplied to maintain a suitable nitrogen-potassium balance. The orchardgrass was clipped 3 times and the ladino clover was harvested after an 8-week growth period and dry weight of tops and roots determined.

Ladino clover seedlings grown alone produced more dry weight than when grown in competition with established orchardgrass. The differences, however, generally were small. Further refinements in techniques have now been developed to determine whether the clover seedlings were retarded by the association with established orchardgrass roots in the nutrient solution or by factors not adequately controlled in the present study.

Growth of ladino clover seedlings in association with orchardgrass was not significantly different whether the nutrient solution was changed twice per week or was not changed during the 8-week period.

Competition for Potassium by Alfalfa and Orchardgrass Seeded in Alternate Rows

Data were obtained for the second harvest year from a field plot experiment to estimate competition for K between alfalfa and orchardgrass seeded in alternate and in mixed rows with different rates and placements of K fertilizer.

Insufficient rainfall again limited forage production. Potassium fertilization produced little if any increase in yield. The alternate-row method of seeding appeared to show some advantage over the mixed-row seeding. Alfalfa and grass are being analyzed for potassium.

As in the previous season low rainfall severely limited orchardgrass growth, and for the second harvest approximately 90% of the forage consisted of alfalfa, reemphasizing the ability of alfalfa to utilize water from the lower soil horizons. The percentage alfalfa in the forage was higher in alternate-row than in mixed-row seedings.

REPORTS OF R. AND M. COOPERATIVE RESEARCH

Title: PROJECT NE-9 - THE INTRODUCTION, TESTING, MULTIPLICATION, AND PRESERVATION OF POTENTIALLY VALUABLE PLANTS FOR CROP IMPROVEMENT AND INDUSTRIAL USE

Leader: H. M. Munger, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs and New Haven), Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Cornell and Geneva), Pennsylvania, Rhode Island, Vermont, West Virginia, Soil Conservation Service, Cooperative State Research Service, and the New Crops Research Branch, ARS-USDA.

The complete report, in respect to forage crops, listed accessions of legumes and grasses which were noted as promising in the Geneva nursery. The number tested was 1082. Alfalfa, in the second year of growth, was examined for vigor, leafiness, winter hardiness, spring recovery, recovery after cutting, and tolerance to disease and insects. The most promising ones included 3 from Afghanistan, 2 each from France, Yugoslavia, and Italy, and 1 each from Poland, Argentina, Australia, England, Iran, and U.S.S.R. Seventeen alfalfa introductions were selected as having tolerance or resistance to blackstem. A number of older alfalfa introductions were selected as promising and regrown for seed increase.

Red clover was examined for upright habit, vigor, leafiness, winter-hardiness, good spring recovery, persistence, and relative freedom from disease and some plants were selected as promising, 6 each from U.S.A. and Sweden, 3 from Finland, 2 each from U.S.S.R. and Great Britain, and 1 each from Columbia, the Netherlands, Iran, Belgium, Poland, Greece, Canada, and South Africa.

The 1964 plantings of ladino white clover were reduced by drought and leafhoppers, but a number of plants was promising from the standpoint of vigor, leafiness, degree of spread, winterhardiness, spring recovery, and freedom from disease and insects. Those selected as promising included 3 each from New Zealand and Denmark, 2 each from U.S.A., the Netherlands, and Italy, and 1 each from Israel, Australia, and Sweden. Of 4 which appeared promising for drought resistance, 2 were from the U.S. and 1 each from Australia and Israel. In the 1963 plantings there were additional promising clovers, 4 from France, 2 from Spain and 1 each from Yugoslavia and Ireland.

In the 1964 plantings of birdsfoot trefoil, a number displayed good winterhardiness and good spring recovery, viz., 3 each from U.S.A. and U.S.S.R., 2 each from Yugoslavia and France and 1 each from Italy, Poland and Chile.

Among grasses which appeared promising in the 1964 plantings were 2 of tall oatgrass (Turkey, U.S.A.), 5 of tall fescue (Yugoslavia 2, South Africa 1, Tunisia 1, and the Netherlands 1), 2 reed canarygrass (Iran, Denmark), 1 smooth brome grass (U.S.S.R.), and 3 timothy (Belgium, Denmark, the Netherlands). They were selected on the bases of freedom from leafspot, vigor, recovery, etc. Other grasses from a 1965 planting already showed promise in the first year.

Work planned for next year is the screening of alfalfa introductions for resistance to black stem, screening of timothy for resistance to stem and leaf rust, and of tall oatgrass for resistance to crown rust.

Title: PROJECT NE-13 - STUDIES OF THE PHYSICAL PROPERTIES, BEHAVIOR, AND FORMS OF FORAGE AS RELATED TO ENGINEERING APPLICATION

Leader: W. L. Kjelgaard, Chairman, Regional Technical Committee

Cooperators: The twelve Agricultural Experiment Stations of the Northeast Region, Agricultural Engineering Research Division-ARS, and Cooperative State Research Service-USDA.

Tensile strength of alfalfa and grass haylage demonstrated linear correlation with dry matter density. Lateral shear strength analysis of haylage also resulted in linear correlation with density as did previously reported vertical shear data. The lateral plane shear values were consistently lower than comparable vertical shear values. Results of an experiment to determine the effect of curing methods on the compressive strength of alfalfa showed essentially no difference in strength due to curing method or to time in storage. The relationship between weight per unit length and the slope of the bending curve for alfalfa stems proved to be linear and increased with age of the plant, and as the moisture content decreased from 60% w.b. to the oven dry state. A decrease in shearing stress for corn from the bottom to the top of the stalk was found. A significant difference in shearing stress of corn stalks was found due to age of the plant.

Hay wafering tests show that teflon has no advantage over other non-corrodible materials for the compression ram face. A toroid shaped ram face resulted in wafers with more uniformly square ends than those from a flat ram face. For unrestrained extruded wafers, 80 to 90% of the 24-hour expansion takes place in the first 15 minutes.

Stomatal influence on the drying rates for alfalfa leaves and orchardgrass has been established. Three degrees of stomata opening were selected for alfalfa, i.e., closed, fully open, and 25 to 50% open. Stomata which were partially open permitted essentially the same mass transfer rate as those fully open. Drying tests on grass were restricted to stomata conditions

either closed or open. Results substantiate theory that drying rates would be affected by the degree of stomata opening, but open stomata showed only slight increases in drying rate over closed stomata.

A relationship between dielectric property "Q" and moisture content of forage proved linear for moisture contents below 40% w.b. The test environment had a pronounced effect upon the relationship of "Q" to moisture content. The frequency of 20 megacycles (mc) was the most sensitive and a frequency of 35 mc had the best accuracy. The relationship holds for forages of homogeneous moisture content and for mixtures of forages with a range of moisture contents.

Experiments were conducted to determine if forage plant moisture was held physically. Samples were centrifuged for ten minutes at various speeds. The results of centrifuging indicated that much of water was being held physically and could be removed by centrifugal force. Steaming, rolling and crimping treatments were also included in the centrifuging experiments. All treatments were effective in accelerating moisture removal.

Drying test data of pelleted alfalfa were compiled and compared with similar data obtained from baled hay. Results of the comparison indicate pellet drying rates of about 1/2 that of the baled hay. The formation of hay pellets by compression impedes further drying.

Tests of pneumatic handling of chopped forage in a 12-inch diameter pipe were completed. The results were developed into a family of curves, showing the relationship between handling rate, pressure drop and air velocity. Air flow resistance tests of hay pellets and wafers were completed and the results summarized.

USEFULNESS OF FINDINGS:

Identification and classification of the mechanical properties of alfalfa and corn will permit more direct computations to be made in the design of forage harvesting machinery. These data may also be useful to other scientists working in the plant field.

Test results indicate that a meter to measure the moisture of forage, based upon "Q" readings, can be developed for the lower end of the moisture range. This represents an improvement over conductance type meters as accuracy is maintained for mixtures of forages with a range of moistures.

Theory involving the mass transfer for partially or fully open stomata has been substantiated when applied to the forage drying process. Drying periods for forage particles at high temperature were established; these data may be useful in the design of processing systems. Data obtained on the physical bonding of forage moisture have led to a more complete understanding of basic phenomena in the release of moisture from drying alfalfa. Drying of hay pellets proved to be more difficult than drying baled hay.

The air flow resistance characteristics of hay pellets and wafers, both clean and with fine particle content, have been expressed in a form which supplements the air flow information of other agricultural products.

The publication of results on vertical shear, lateral shear and tensile strength of haylage masses, as they occur in storage, provides for more objective and precise design of storage and handling equipment.

Title: PROJECT NEM-22 - FACILITATING THE MARKETING OF SEEDS THROUGH IMPROVED TESTING PROCEDURES

Leader: L. W. Nittler, Chairman, Regional Technical Committee

Cooperators: Maine, Maryland, Massachusetts, New Jersey, New York (Cornell and Geneva), Pennsylvania, and Rhode Island Agricultural Experiment Stations, Forage and Range Research Branch, Biological Science Branch, ARS-USDA, Seed Branch Consumer and Marketing Service, and Cooperative State Research Service-USDA.

In New York red fescue varieties were grown with continuous light and temperatures of 21°C for 20 hours and 5°C for 4 hours. Fifty percent of the plants of a commercial seed lot were decumbent as compared to 22% for Pennlawn, 17% for Illahee, and 14% for Chewings. Fewer decumbent plants developed if shorter or less intense cold periods were used. The plants varied from green color at the base of the stems to very intense red. Green stem color was correlated with decumbent growth habit.

Kentucky bluegrass varieties grown with continuous light and 21°C temperature developed intense red color at the base of the stems of 6 varieties. Two varieties had moderately red stems and 2 had green stems. Varieties also differed in tiller and rhizome number, leaf width, and in the angle of leaves with the stem. The pattern of upper epidermal cells of leaves of 10 varieties of Kentucky bluegrass was studied using a method described by the late Professor Stoddard of the Connecticut Agricultural Experiment Station. Varieties differed in size and shape of cells as well as in presence or absence of leaf hairs.

Growth chamber methods of promoting heading of timothy and annual ryegrass were developed. Since perennial ryegrass does not head under the conditions used, plants of annual ryegrass can be separated easily from those of perennial ryegrass on the basis of heading. When grown with continuous, high intensity light and temperatures of 24°C for 22 hours and 16°C for 2 hours, 99% of the plants of Florida Rust Resistant, 52% of those of Gulf, and 74% of the plants from a commercial seed lot headed within 5 weeks of the time the seed was planted. In similar experiments with timothy an average of 86% of the plants of 3 varieties headed in 5 weeks. Best results were obtained with temperatures of 21°C for 20 hours and 10°C for 4 hours.

Timothy and orchardgrass varieties differed in the percentage of plants with reddish purple pigmentation at the base of the stems. Timothy varieties ranged from 14% of plants with red stems for Essex to 42% for Climax. Orchardgrass varieties ranged from 18% red stemmed plants for a Virginia experimental line to 67% for Frode and 77% for Aurora. Development of red stems could be induced in both species by cold dark periods or by soil treatments with maleic hydrazide.

A low concentration of B-995 sprayed on 20-day-old seedlings of 6 varieties of alfalfa grown in a growth chamber caused a highly significant increase in percentage of plants in bloom 5 weeks after planting.

Maleic hydrazide treatments were useful in distinguishing Viking birdsfoot trefoil plants from common European. Forty-three percent of European plants were killed by a 0.125% spray when the plants were 3 weeks old as compared to 28% for Viking. Differential response in growth habit occurred when the soil was treated with a weak solution of maleic hydrazide. Only 3% of the European plants were classed as upright 4 weeks after treatment as compared to 14% for Viking.

In Pennsylvania, studies were continued on the use of flower and leaf color in trueness-to-type testing in alfalfa. Plants were grown under standard conditions of temperature, light, and soil fertility. Flower color of the standard petal was measured directly on a color-coder and by extraction of flower pigments and measurement on a B and L Spectronic 20. Cotyledon and leaf colors were measured on the B and L Spectronic 20 after extraction with acetone. Significant varietal differences were found in both leaf and flower color for 10 varieties of alfalfa. This work is being extended to measure flower and leaf color of 2 seed lots each of 50 to 60 varieties of alfalfa. In addition flower and leaf colors are being studied in 18 unknown seed lots of alfalfa. Studies are also continuing on the effect of temperature, soil pH, and fertility on the expression of flower color. Effects noted thus far have been minor.

Data on varietal variation in internode length and number in 10 varieties of alfalfa have been summarized. Significant varietal differences were found.

In studies to ascertain if alfalfa varieties differ in chemical content of the seed, 2 seed lots each of 14 different varieties were analyzed for their content of 11 elements. Significant differences in element content and in ratios of 1 element to another occurred.

The technique of rapid induction of flowering in forage legumes was studied at greater length. Plants of alfalfa, red clover, and birdsfoot trefoil can be induced to bloom in 3 to 4 weeks from date of seeding by subjecting them to continuous light and temperatures of 35 to 40°C.

Studies were continued on varietal differences in crownvetch with respect to seed weight, cotyledon size, and seed coat color. Significant varietal differences were found.

Studies were continued on the use of paper, thin layer, and gas chromatographic techniques to detect varietal differences in crownvetch, alfalfa,

birdsfoot trefoil, orchardgrass, and bluegrass. Varietal differences have been noted but procedures need to be refined. Accordingly, considerable time was spent testing various solvent systems, extractants, and support media.

In order to study the use of serological techniques in trueness-to-type testing, a rabbit colony was established and anti-bodies are being built up for several varieties each of crownvetch and bluegrass. Studies are also underway on the use of multivariate numerical and graphical analysis techniques in trueness-to-type testing.

Under another objective, to find better measures of the performance potential of seeds, were the following accomplishments:

In Massachusetts studies were made to determine if the dissolved oxygen analyzer can be used to measure oxygen consumption of seeds during flood tests and if oxygen uptake can be related to field germination. Oxygen uptake by sweet corn seed was found to be greatly affected by oxygen concentration of the water. In 200 ml of water with 1.58 mg of dissolved oxygen 2 seeds absorbed 64.6% of the oxygen whereas 100 seeds absorbed 94.3%. Treated sweet corn seed consumed less oxygen than untreated seed. It appeared that the best of 3 grades of treated sweet corn seed consumed less oxygen than the poorest grade during the cold period of a flood test.

Flood tests of sweet corn and bean seed with or without soil gave germination results closely related to field emergence. Both good and poor lots of peas subjected to flood tests without soil but with limited oxygen gave laboratory responses closely related to field results. Differences in consumption of oxygen could not be related to field results.

Results with the galvanic cell oxygen analyzer showed that it can be used to measure oxygen uptake of seeds if care is taken to exclude air spaces and bubbles from seeds and bottles. In addition analyzer must be calibrated against a known sample within a few hours of its use.

In New York temperatures were recorded at various points in 4 new germination chambers of advanced design. Variation in temperature from one location to another was observed. In general, the variation was less than that previously observed in older types, but some locations were 2 or 3°F cooler or warmer than others.

In Pennsylvania a study is being made of stress tests to evaluate vigor in reed canarygrass seed. Cold, flood, and aerobic hot tests as well as accelerated aging and acid were used on 21 seed lots and the results related to standard germination tests and to field emergence.

USEFULNESS OF FINDINGS:

Methods developed to test forage and turf species for varietal purity are proving to be of value in providing the consumer with seed that is correctly labeled. Samples of seed are being tested for seed companies and law enforcement agencies using methods developed under this project. In most cases the results are available in 4 or 5 weeks. In some cases results are used by seed companies to determine how to label seed stocks. Other results are used by law enforcement agencies to point out inaccuracies in labeling to seedsmen.

Information is being obtained on the use of cold, flood and other stress tests to evaluate seed stocks for ability to germinate under adverse conditions. These tests will be of value to seed users in choosing seed stocks for planting in situations where adverse conditions are likely to be encountered.

Data on the performance of seed germinators have aided in designing units that provide more nearly uniform conditions throughout the germinator.

Title: PROJECT NE-24 - NUTRITIVE EVALUATION OF FORAGES

Leader: R. W. Hemken, Chairman, Regional Technical Committee

Cooperators: The 12 Northeastern States, the U. S. Regional Pasture Research Laboratory, Dairy Cattle Research Branch, ARS, and the Cooperative State Research Service, USDA.

The objectives of this regional project are: (1) to evaluate forages of various species and varieties grown under known conditions and harvested at specific dates and stages of maturity by determining the digestibility of energy and protein and the daily consumption rate; in fewer instances, forages will be evaluated in terms of animal production responses and energy balances, and (2) to determine the fundamental conditions controlling the amount of forages ingested by ruminants and to develop methods for measuring and predicting the daily forage consumption rate.

Various factors influencing the nutritive value of forages as measured by daily rate of consumption and digestibility were studied during the past year by many of the stations. Factors studied were: (1) cutting date and growth stage (Maine, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia, and Dairy Cattle Research Branch (ARS); (2) forage varieties within a species (Delaware, New York, Pennsylvania, and Dairy Cattle Research Branch (ARS); (3) effect of regrowth interval on aftermath growth (Delaware, Maine, Maryland, New Hampshire, New Jersey and Vermont); (4) nitrogen fertilization (Delaware, Maryland, Rhode Island and West Virginia); (5) phosphorus fertilization (Maine and West Virginia);

(6) physical form of forage (New York); (7) method of storage (New Hampshire); and (8) trace element fertilization (West Virginia).

Preliminary analyses of effects of environment upon voluntary intake with sheep indicate that increasing room temperature tends to decrease levels of voluntary intake (Delaware). Level of refusal (0 to 40%) on intake and digestibility with sheep resulted in an increased intake and decreased digestibility as level of refusal was increased (West Virginia). Studies comparing sheep and steers indicate coefficients of variation in intake per unit of body weight to the power of 1.0, 0.73, and 0.84 of 20, 18, and 12%, respectively (New York).

Additional data (Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and the Dairy Cattle Research Branch, ARS, emphasize the importance of early harvesting to obtain the greatest nutritive value. The one exception to this was the result from a corn silage study where the intake increased with stage of maturity (New York). Net Energy, as measured by stored energy with the comparative slaughter technique, decreased with advancing maturity of alfalfa and was associated with increased lignin content (New Jersey). The same relationship of effect of stage of maturity was established with redtop in net energy studies using indirect calorimetric techniques (New Hampshire).

The effect of regrowth interval on the aftermath growth of timothy showed a decline of digestible energy with a later harvest but no change on the ad libitum intake (Maine). Intake was inversely related to harvest dates for first growth and aftermath harvests of orchardgrass when compared by cafeteria type ingestion measurements (New Jersey). Three varieties of alfalfa were compared by intake and digestibility trials when harvested either 3 or 4 times during the growing season (Dairy Cattle Research Branch). While only small differences were found among varieties, the hays cut 3 times averaged about 4 units lower in digestible dry matter content than those harvested 4 times. In addition, second crop hays were less digestible than earlier or later crops.

The use of trace minerals gave increased yields of regrowth cuttings but reduced intake on first cuttings and increased digestible dry matter on regrowth cuttings (West Virginia). Nitrogen fertilization showed increased dry matter digestibility with 50, 150, and 450 lb levels when compared to 0 levels of nitrogen; however, little effect of nitrogen level was noted on intake (West Virginia).

The concentrations of dissolved Na, K, Ca, Mg, and P in the rumen contents of cattle fed reed canary hay and the same forage as fresh grass or various ratios of reed canary hay and corn silage have been studied (Massachusetts). Some of the mineral levels changed with the form in which forage was fed, level of intake, and the kind of forage. Volatile fatty acids (VFA) levels were measured in both the rumen and systemic circulation of steers at initiation and termination of eating (Maine). Rumen VFA levels were higher at termination than at initiation but no differences were found in the respective VFA concentrations in the systemic circulation. Twice daily feeding trials showed large differences in rumen dry matter content before

and after feeding but no significant differences were noted for animals which were fed ad libitum. The effect of introducing undigestible fibers of polypropylene into the rumen resulted in reduced voluntary intake and the reduced intake was more prolonged as the length of fiber was increased (New Jersey).

Chemical composition was further related to nutritive value. Total hemicellulose was studied in bluegrass and alfalfa and found to be negatively correlated with digestibility but not with voluntary intake. Cellulose and its digestibility were negatively correlated with intake in orchardgrass, bromegrass and sudangrass, but not in other species. In timothy total hemicellulose increased up to May 19 and remained fairly constant thereafter (U. S. Regional Pasture Research Laboratory).

Cell wall constituents and acid detergent fiber have been found in forages to be more precise chemical entities than crude fiber (New Jersey). Improvements in the procedure for cell walls using neutral detergent have eliminated the interference of starch (Dairy Cattle Research Branch). An in vitro rumen procedure which yields true digestibility directly has been developed based on the cell wall method, and is more accurate than the Tilley method for estimating apparent digestibility. True digestibility in vivo can be calculated from fecal cell wall analysis and the bacterial and endogenous excretion estimated. On this basis a new summative equation for predicting digestibility from lignin and cell walls has been developed.

USEFULNESS OF FINDINGS:

Data accumulated from all stations of the region on the relationships of cutting date and maturity to the yield and nutritive value of forages will serve as the basis for recommended management practices. Equations based on chemical composition are being developed to predict nutritive value as determined by digestibility and intake trials.

Plant geneticists are being aided in the development of new forage varieties by giving them methods by which they can obtain a prediction of the nutritive value of the forages at an early stage of development.

The work on fertilizer treatments and rumen function provides basic information concerning factors which may affect intake or digestibility of forages.

The work projected for the coming year will be a continuation of that in progress. Special emphasis will be given to: (1) further development and use of chemical methods to be used for the nutritive evaluation of forages; (2) the effects of fertilization with nitrogen, trace elements, and phosphorus on the nutritive value; (3) factors affecting rumen fermentation of forages; (4) basic factors affecting intake of forages such as body size and rumen fill; (5) relationship of various constituents to digestibility and intake; and (6) continued examination of the interactions between methods of harvesting and storing of forages and the nutritive value.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST

Leader: R. W. Cleveland, Chairman, Regional Technical Committee

Cooperators: Connecticut, Maryland, New Hampshire, New York (Cornell), Pennsylvania, West Virginia, the U. S. Regional Pasture Research Laboratory, the Forage and Range Research Branch, ARS, the Cooperative State Research Service, USDA, and the American Seed Trade Association.

Breeding and evaluation for 6 forage species were conducted in programs in 8 Northeastern states and the U. S. Regional Pasture Research Laboratory. Seed production of experimental materials for strain synthesis investigations and regional evaluation studies was continued in 3 states for 6 forage species.

Regional evaluation of new synthetic varieties of forage crops—Alfalfa, timothy and birdsfoot trefoil trial series to test the performance of several new varieties originating at the New York experiment station were harvested in the following states in 1965 and new plantings were made.

1964 Alfalfa varieties — Connecticut, Maryland, New York (5 locations), Pennsylvania (2 locations), and Vermont.

1965 Alfalfa varieties — Connecticut, New York (3 locations), and Pennsylvania (3 locations).

1965 Birdsfoot trefoil — New York (3 locations), and Pennsylvania (1 location). Nine experimental synthetics (Seaney, New York) are being tested in this trial series.

1964 Timothy varieties — Connecticut, Maine, and Vermont.

Most of these trials were established successfully in both years. Some failures due to drought were experienced in 1964, and some 1964 experiments may not succeed for the same reason. Forage yield results reflected the water shortage in low yield levels and decrease in trial precision. Data in additional years will be necessary before reliable conclusions may be drawn.

Fifth-year data were obtained from 1960 series alfalfa variety trials in New York. Data collections were terminated in all other states, or at some locations were continued on a limited basis. The results of this experiment, which included management differentials, were excellent and have contributed a great deal to decisions for release of the variety Saranac by New York. An early generation precursor of the variety Mark II, also released by New York, was tested in this regional evaluation.

Cooperative forage breeding studies—Orchardgrass—Data were obtained in 1965 at New York and Pennsylvania for 3 polycross progeny trials to evaluate the yield of 66 parental clones segregated into medium early, medium late, and late maturity groups on the basis of heading date. Data taken to date are comprised of 2 years' forage yields from Pennsylvania and 3 years' yields from New York. Several progenies are high yielding in comparison with check varieties, indicating that the respective parental clones might be useful in new synthetic formulations.

Progress was made toward development of a "non-flowering" orchardgrass in studies originating at the U. S. Regional Pasture Research Laboratory in cooperation with Vermont. Syn 1 seed of three 4-clone synthetics was compared in solid-seeded plots planted near Burlington, Vt. and University Park, Pa. Panicle counts on both experiments indicated a genetic basis for low panicle production. Contents of lignin, cellulose, and hemicellulose were also measured and one synthetic (Syn C) was found to be lower in these components than Pennlate orchardgrass, indicating improvement of quality of first cut forage. Forage yields of the 3 synthetics were lower but were not statistically different in Pennsylvania. Whether higher forage quality will compensate for apparent reduced forage yield remains a question to be answered with additional yield data of future years.

Bromegrass—A polycross progeny trial established in 1962 is under evaluation at both Pennsylvania and New York. Data were obtained in 1964 at both locations. Progeny information and experimental synthetic performance indicate these materials will produce a higher yielding variety than Saratoga. Seed yielding capacity is not known.

Seed production of 2 synthetics formulated with disease resistant bromegrass clones at the U. S. Regional Pasture Research Laboratory was accomplished in 1965. The parent clones have resistance to Helminthosporium bromi, Stagonospora bromi and Rhynchosporium secalis. Syn 1 seed was obtained in the greenhouse in 1965. Also nurseries for the production of Syn 2 seed and additional Syn 1 seed were established in the field. By 1967 sufficient seed should be produced for extensive testing of the 2 synthetics (designated Syn D and Syn E). An effort will be made to evaluate any effects of leaf disease resistance on recovery growth and forage quality of smooth bromegrass. The formulation of these synthetics is the result of a cooperative effort in progeny testing by USDA and New Hampshire personnel.

Alfalfa—The simultaneous evaluation of forage and seed yield potential of polycross progenies of 65 disease resistant alfalfa clones with Vernal germplasm is underway in Pennsylvania, Minnesota, and Utah in cooperation with the U. S. Regional Pasture Research Laboratory. Forage yield data from the second harvest year were obtained from Pennsylvania and Minnesota. Loss of stand prevented further studies of the seed yield experiment in Utah in 1965. Conclusions from this trial are deferred until complete summaries of data are made.

Variety synthesis studies for perennial forages—Investigations of synthesis procedures are in progress for 6 species: alfalfa, birdsfoot trefoil, timothy, brome grass, orchardgrass and ryegrass-fescue hybrids. Although field evaluations of experimental materials have begun for alfalfa and timothy, a large part of the current work is in the production of seed for future studies. The seed production phases are being carried out mostly by use of isolation cages or field isolation nurseries located in New York, Pennsylvania, and New Hampshire. Seed production in 1965 was fair to poor depending on the species and type of planting. The scope of seed production phases is outlined below:

A. Seed Production Phases:

New York, isolation cages for:

Birdsfoot trefoil - Seed was produced of 2 new synthetic combinations not yet tested, and 9 older formulations now in test.

Alfalfa - 25 total, including 15, 12' x 24' cages and 10, 12' x 12' cages. These comprise double-cross combinations (some for materials carrying the multileaf marker) and advances of parent single-crosses.

Timothy - 63 total, 8' x 16'. Isolation cages included plantings for the production of seed from:

1. Generations of single-clone derived lines
2. Single-crosses between clonal lines
3. Single-crosses between clones
4. Double-cross combinations

Plantings were made in 1965 for additional production in 1966 as follows:

Timothy, 18 isolation cages (8' x 16') for the production of increases and crosses of single-clone derived lines;

Brome grass, 24 small isolation cages (4' diameter) for single crosses of mutant clones.

Pennsylvania - Orchardgrass

16 isolation cages (4' x 4') for production of S₁ seed of orchardgrass clones.

Field isolations - Syn 2 seed generation was produced for 11 synthetics constituted on regional performance.

Plantings for cage isolation were made in 1965 including 6 crossing blocks for production of double-crosses. Eleven nurseries for the production of single-crosses failed to flower in 1965 and were held over for 1966 production.

New Hampshire - Bromegrass

Field isolation - Syn 1 and Syn 2 seed were produced from 4 synthetics involving 3, 4, 5, and 6 parental clones each. Syn 2 seed was produced from two 2-clone synthetics.

Cage isolation - Three large cages and 9 small cages were planted, including respectively (1) S₁ plants from 3 different bromegrass mutants and (2) 9 single-cross combinations of bromegrass mutants. Practically no seeds were produced in any cage although flowering was satisfactory in most of them. The reasons for the failure are obscure at this time.

U. S. Regional Pasture Research Laboratory - Ryegrass-Fescue Hybrid Derivatives

Eight 4-clone synthetics composed of backcross derivatives of ryegrass-fescue hybrids were constituted. Syn 1 seed was produced in the greenhouse and nurseries were established for the production of the Syn 2 generation. Additional Syn 1 seed will be produced from parent clones in field nurseries for which isolation cages will be constructed. Comparative tests of Syn 1 and Syn 2 generations of the 8 synthetics are planned. A new cycle of selection, involving chromosome number determinations, is continuing for ryegrass-fescue derivatives which have been crossed to tall fescue.

B. Evaluation Phases:

Alfalfa - Forage yield data were obtained in 1965 from alfalfa synthesis trials I and II at New York, and from trials III, IV, V, and VI at New York (2 locations each) and Pennsylvania (1 location). The accumulated data show:

1. Stabilized synthetics to be consistently superior to double-crosses made from the same clones.
2. Differences exist among the possible double-cross arrangements of 4 parent clones in some combinations tried.
3. Differences appear to exist in double-cross performance when double-crosses are produced using different seed generations of the single-cross parent lines.
4. Differences in crossed and sibbed seed ratio as affected by planting arrangements of parent lines have been demonstrated in yield performance of cage-produced combinations. Comparisons of seed mixtures for crosses made without pollination control and the included sib-produced fractions show a definite advantage for true crossed seed.
5. Comparisons of performance of all possible 2-clone synthetics from a population of 4 clones with the synthetic from all 4 parents indicate a definite disadvantage in restricting the gene base to 2 parents. This about equals the usual hybrid advantage in using first generation seed.

A new trial to test the double-cross products of different seed cage procedures was established in New York and Pennsylvania in 1965. The results of this trial may verify inferences that different seed cage procedures affect the amount of cross-pollination and thus affect the performance of the product.

Timothy—Evaluation trials for synthesis materials were planted in New York and Pennsylvania in 1965. Establishment was not satisfactory in Pennsylvania. Field data were obtained on trials established in 1964 at New York. A definite one to three day shift in maturity toward earliness in the development of single-clone derived lines from late-maturity parents was conclusively demonstrated. This is attributed to seedling competition and the relationship between earliness and seedling vigor. Anthesis date is being studied in seed production cages and in row plantings of study materials.

Birdsfoot trefoil—Extensive studies by R. Seaney and co-workers have been made concerning the influence of seed cage procedure on the amount of crossing occurring during synthesis. A gene controlling the production of HCN has been used as a marker in these studies. Results have indicated that self-fertile clones in crossing blocks produce selfed seed in proportion to their self-fertility index. An assessment of the effects of self and/or sib seed mixtures with cross seed on field plot performance was carried out in experiments initiated in 1964 and 1965. In one experiment for the period from May to September, 1965 the percent of self and/or sib seedlings in field plots was found to decrease by a factor of one-half. The results indicate a greater survival of cross seedlings than self and/or sib seedlings during the year of establishment.

Orchardgrass—A broadcast plot trial to evaluate 11 regional synthetics in both Syn 1 and Syn 2 generations was established at Maryland, New York, and Pennsylvania. Initial stands appeared to be satisfactory at the 3 locations.

Bromegrass—Syn 1 and Syn 2 generations of a diallel single cross test of 6 bromegrass clones were evaluated for the third year in 1965 at New Hampshire. Analysis of the 1965 forage yield data gave significance due to crosses. Variation due to generations was highly significant as it was in both 1963, and 1964. A few crosses, however, show slight change from the Syn 1 to the Syn 2. This trial was repeated in a 1964 field planting for which forage was harvested in 1965, but yields were reduced because of drought. A similar trial including 3, 4, 5 and 6-clone synthetics in both Syn 1 and Syn 2 generations was well established in 1965.

At New Hampshire and New York, efforts are being made to obtain bromegrass mutants which may be useful for genetic study or for pollen dispersal and other studies on strain synthesis. Several have been found including at least 2 chlorophyll mutants, one mutant with rolled leaves, and dwarf plants. Clearcut segregation occurred in seedling F_2 progenies for a "white" mutant in a New Hampshire test, although expression varied with environment. Maximum expression occurred under short photoperiod at 60°F in the greenhouse. In the field, the mutant phenotype is expressed on mature plants only in the spring. Similar material has been found in orchardgrass at New York. Character expression is triggered by temperatures.

USEFULNESS OF FINDINGS:

The release of several forage varieties by state experiment stations of the Northeastern region has been facilitated by performance information gathered from NE-28 experiments over several years:

- (1) Alfalfa—Saranac and Mark II have recently been released. Other experimental varieties have high potential and are under consideration.
- (2) Orchardgrass—Pennmead, a medium maturity variety.

Trials of polycross progenies and synthetics are a very valuable source of information concerning forage productivity, quality, disease resistance, tolerance to different managements and stand longevity. The assessment of characteristics of experimental forages, along with information about geo-climatic-genotypic interactions that may exist, is essential to the formulation of superior forage varieties with the widest possible adaptation in the Northeast. For most species, experimental varieties being studied in current trial series represent the culmination of 20 or more years of breeding research.

The seed production phases of NE-28 research were instituted for several purposes: to test breeding methodology theory; to find new means to utilize heterosis in forage plants; to devise new methods for forage improvement whereby a shorter time may be required from initiation of breeding work to farmer use of improved products. Commercial seed production of forages may be facilitated through improvements in efficiency and lowering of costs if practical new techniques of variety synthesis and seed production can be devised. Genetic studies utilizing mutants will help develop tools for use in studying synthesis procedures. The work with birdsfoot trefoil reported this year and previously especially illustrates the potential of mutants for use in breeding methodology studies.

All trial series established in 1963, 1964, and 1965 for regional synthetic evaluation, polycross progeny testing and variety synthesis investigations will be maintained and data will be collected.

New plantings will include variety synthesis evaluation trials for timothy, birdsfoot trefoil, and brome grass.

Seed production of experimental materials for use in planned future studies will be carried out as indicated in detail in the previous section.

Title: PROJECT NE-29 - MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSES OF PERENNIAL FORAGE GRASSES

Leader: W. H. Mitchell, Chairman, Regional Technical Committee

Cooperators: The 12 Northeastern States, The Forage and Range Research Branch, the U. S. Regional Pasture Research Laboratory, ARS, and the Cooperative State Research Service, USDA.

The project has the following objectives:

1. To measure the effects of management and environment on the morphological development and growth rate of perennial forage grasses.
2. To evaluate the factors which influence the accumulation and depletion of food reserves in perennial forage grasses.
3. To establish the nutritional value of forage samples grown under specific management systems.

Objective 1. Climax timothy yields were influenced by timing and rates of nitrogen fertilization (Rhode Island). Highest yields were obtained when the total nitrogen was applied in early spring as compared to split applications of similar amounts applied 10 or 20 days prior to the first harvest. High nitrogen applications increased the number of headed tillers and decreased the leaf-stem ratio in the first growth. First cutting yields were increased as the stage of maturity was advanced from late boot through early bloom. A similar response was obtained by delaying the harvest of Climax timothy and reed canarygrass (Pennsylvania). The leaf-stem ratio of the first harvest material decreased as harvest was delayed from the vegetative to early heading stage of growth. The reverse was true of the first aftermath.

Soil moisture and fertility greatly altered the growth and development of potted plants of orchardgrass, brome grass, Kentucky bluegrass, and timothy (West Virginia). Plants were grown at widely separated locations under a variety of environmental conditions. All species, except brome grass, made their maximum growth under high rainfall and cool temperatures. Growth chamber studies with the same 4 species were conducted to determine optimum temperatures and the relative importance of day and night temperatures. Each species was grown under 36 temperature regimes.

The residual effects of differential fall defoliation of Climax timothy (1 1/2-, 2 1/2-, and 4-inch stubble heights), as measured by a boot stage harvest, were not significant (Maine). Stem elongation in the spring of both Climax timothy and reed canarygrass was more rapid when fall defoliation was at 3 1/2 as compared to 1 1/2 inches (Pennsylvania). Stem elongation of reed canarygrass was initiated about 1 week earlier than Climax timothy, although the latter proceeded at a more uniform rate, especially during the late boot stage of development.

Reference plants (large dominate stems) were found to give a reliable indication of the morphological development of reed canarygrass populations in general (Connecticut). Clonally propagated material minimized variability encountered in earlier attempts to relate morphological changes to regrowth potential.

Reed canarygrass propagules were divided into 3 distinct and useful units for purposes of understanding the nature of competition in bud development (New York). When old rhizomes were isolated from culm bases and new rhizomes, their buds remained active. However, with intact propagules apical dominance was observed, which produced an inhibition of the old rhizome buds. When culm base buds and new rhizome buds were removed the old rhizome bud inhibition was fully relieved. Inhibition was partly restored by the application of NAA to the bud scars.

Potomac orchardgrass was grown for the second year under 4 soil temperature regimes, 2 light intensities, 2 nitrogen levels, and 2 stubble heights (Maryland). Forage production was greatest at 50°F, and least at 90°F. Shade also decreased forage production. Nitrogen increased forage yields even though stands were reduced. The greatest stand reduction was on high temperature plots, under shade with high nitrogen applications. Yields were generally higher with low stubble, but stands were often reduced. This reduction was greatest in plots receiving high nitrogen, under high shade or with high soil temperature.

Objective 2. High soil temperatures reduced fructose content of Potomac orchardgrass as did shade and high nitrogen treatments (Maryland).

Accumulation and depletion of stored carbohydrates in rhizomes of reed canarygrass were related to the morphological development of reed canarygrass clones (Connecticut). A decline in stored carbohydrates was associated with initial plant growth. An accumulation of carbohydrates began when the reference plants were 9 inches tall. A second decline in carbohydrate storage occurred when elevation of the growing point was initiated. Within an 11-day period there was a 41% reduction. Depletion and accumulation of total carbohydrates were closely associated with changes in fructosan, which was the predominant storage form.

Heavy applications of nitrogen reduced carbohydrate reserves of orchardgrass to critically low levels during periods of high temperature and low soil moisture resulting in reduced growth and loss of stands (Massachusetts). The percentage of fructose in corms of Climax timothy increased as harvest was delayed from the boot stage to full head and early bloom stages of growth (Rhode Island). Fructose was reduced by high nitrogen fertilization.

Objective 3. The nutritive value of forages produced under the harvest schedules of the previous NE-29 project was assessed in cooperation with the NE-24 group. Climax timothy was produced and harvested, under the A, B, and C treatments of the previous NE-29 study, for digestibility and intake trials with sheep (Maine and Vermont). A small improvement in forage quality resulted from the prejoint clipping prior to the July harvest (Maine). Climax timothy was grown at 2 levels of nitrogen fertilization and harvested at the late boot and full head stages of maturity for feeding trials with sheep (Rhode Island).

Other Accomplishment. Frit fly infestation of reed canarygrass resulted in complete loss of some research material (Connecticut). A nationwide survey was conducted to determine the seriousness of the problem. Although no clear pattern of distribution was found, it seems likely that in some cases those responding were unable to identify an infestation of frit fly.

Title: PROJECT NE-45 - ROOT AND CROWN DISEASES OF ALFALFA AND CLOVERS

Leader: J. H. Graham, Chairman, Regional Technical Committee

Cooperators: Delaware, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and West Virginia Experiment Stations; the U. S. Regional Pasture Research Laboratory, the Forage and Range Research Branch, ARS; and the Cooperative State Research Service, USDA.

Two- to four-week-old alfalfa seedlings grown under aseptic conditions were used to determine the relative virulence of isolates of Fusarium oxysporum and F. solani, the influence of stress factors in predisposing alfalfa to root rot caused by these species, and the relative resistance of alfalfa varieties to Fusarium root rot (Cornell). Both Fusarium spp. caused more disease in plants grown at pH 5 or at low calcium levels than in plants grown at pH 7 or at normal calcium levels.

At the Pasture Research Laboratory, plots of red clover were established in 1964 to study the effects of insects and soil microorganisms on persistence. By October, 1965, the results indicated that Polycide had no effect on yield or on the number of plants dying. Plots which had received heptachlor or lindane yielded almost twice as much as the controls, and plants under cages were more vigorous and healthier than those uncaged.

Other plots were established in 1964 to study internal breakdown (IB) of red clover. During 1965 a severe infestation of root borers reduced the stand; Pennscott was reduced 37% while the better selections were reduced only 20%. Four strains selected earlier for general persistence were reduced 15%. Roots varied little in size but the IB-resistant selections had 50% less IB than nonselected plants. A large population of the northern root knot nematode was observed in this area for the first time. Pennscott and the IB-resistant selections (originally selected from Pennscott) were moderately resistant to the nematode. Lakeland, Kenland, and the other selections were susceptible.

The identification of some chemical compounds associated with IB was attempted. No differences were found between healthy and IB crowns in their content of free amino acids, determined by paper chromatography, and inorganic elements, determined by an emission spectrograph. With use

of thin layer chromatography followed by paper chromatography, several fluorescent substances, identified as phenols, were isolated from IB tissue.

The virus in all collections of infected red clover plants was identified as red clover vein mosaic virus (RCVMV) (West Virginia). It was difficult to obtain infection in the greenhouse. Preliminary efforts to transmit the virus by aphids did not result in increased transmission. RCVMV readily infects broad bean systemically by mechanical sap-inoculation techniques and crimson clover almost as well. It is lethal to these 2 hosts but not to red clover. Field observations and some laboratory studies indicated that infection with RCVMV predisposes red clover plants to root rotting by Fusarium spp.

Red clover and alfalfa plants were inoculated with a number of Fusarium spp. Root rotting occurred readily but the recovery of the original Fusarium isolate was difficult in the summer. F. moniliforme was the most common contaminant recovered.

A culture medium containing sodium azide and rose bengal is highly selective for Fusarium species and inhibits the growth of bacteria and of Trichoderma.

Laboratory and greenhouse studies were conducted to determine the pathogenic relationships of Fusarium roseum to rotting of root tissues of Pennscoth red clover (New Jersey). Histological studies showed that no penetration of seedling roots occurred until 3 days after inoculation. After that the fungus entered uninjured roots by direct penetration through the epidermis. Four days after inoculation the mycelium was distributed primarily in the intercellular areas of the cortex. Within 5-6 days the fungus completely colonized the cortex, being distributed both intercellularly and intracellularly. After 6 days hyphae were aggregated along the xylem and evidence of occasional penetration was seen. The penetration of the clover roots occurred without the formation of appressoria. It was most abundant at the root tip meristem. Once colonized, the infected roots turned a dark brown and rapidly lost turgidity. Both chlamydospores and macrospores of the fungi were observed in colonized root tissues. The fungus was readily reisolated from infected seedlings grown in the laboratory or greenhouse.

The potential of the Rhizobial-Fusarial interactions on alfalfa seedling growth and root rot was studied, using a culture of Fusarium oxysporum isolated from a diseased alfalfa plant and proved to be pathogenic, and a Rhizobium isolated from alfalfa root nodules (Rhode Island). An antagonism was indicated when F. oxysporum was grown associated with Rhizobia. The in vivo interaction was demonstrated by the use of the axenic Fahraeus culture technique. Nodulation does not develop normally when Fusarium is present previous to infestation of the alfalfa rhizosphere with Rhizobium. Regression of nodule development is a function of the prior duration of exposure of the seedling to Fusarium. Yet, F. oxysporum alone initially stimulated seedling root growth. These observations suggest an explanation of the failure of Rhizobium-treated alfalfa seed to produce nodulated alfalfa seedlings. In Fusarium-infected soils the nitrogen-fixing bacteria fail to enter the roots and the subsequent growth of the plant is not stimulated. Two years' records indicate no correlation between virus infection of alfalfa and longevity of stand.

Anatomical and physiological studies were conducted on white clover (New Hampshire). White clover has 2 systems. The center of the primary system is the crown, which morphologically, is a condensed main stem with the potentiality of producing an unlimited number of stolons. A secondary system originates from the nodes of the stolons and its roots give their support mainly to the branch stolon and very little, if any, to the main stolon. The node produces only one branch stolon instead of many as the crown does and thus has a smaller root system. The node has very little parenchymatous tissue and has little value in storage of food reserves. The disappearance of the white clover is owing to the death of the primary system and failure of the secondary system to replace it. In the latter part of the growing season, the nutrients of white clover, especially of the profusely flowering ones, are radiately polarized away from the crowns and the primary system becomes exhausted. This evidence was obtained by cutting off the stolons and thus prolonging the life span of the primary system.

Of 490 fungal isolates from diseased taproot sections, 50.4% were Fusarium oxysporum and 9.8% were F. solani. The rest were saprophytes and pathogens with about 10% known to be pathogenic on clover. Pathogenicity tests with older plants showed that F. solani was most pathogenic, followed by F. oxysporum and F. roseum, respectively.

Ten strains of white clover were evaluated for root rot resistance by growing them in a bed infested with root rot pathogens and harvesting them at a height of 1 inch every 3 weeks. No strain was highly resistant. Kent and New Zealand were damaged least by the pathogens while Lodi and Idaho were damaged most. Plants grown under low soil moisture (12%) suffered less from root rot than those under high soil moisture (22%). Fertility levels had no apparent effect on root rot development.

Four-year-old roots of varieties of alfalfa (Atlantic, Buffalo, DuPuits, Narragansett, Ranger, Vernal, Williamsburg) were inoculated 1 inch below the crown in May with 10 strains of Fusarium (Delaware). Six months after inoculation no plants had been killed but a moderate amount of decay was caused by F. oxysporum batatas, F. oxysporum lycopersici, and F. oxysporum cubense. Some decay was caused by F. roseum and F. solani. No differences among alfalfa varieties were noted. The other 5 fungi did not cause root decay.

To study the effect of organic matter on root rot, red clover hay was mixed into the soil in a plot surrounded by an aluminum strip. In June, 1965, soybean plants were mixed into the soil in half of the plot. Vernal alfalfa was seeded in August. In October it was noted that the alfalfa plants were large and dark green in the part where the soybeans had been mixed in the soil and yellowish green in the other half-plot. In November it was noted that the primary roots were long and thick with only a few secondary roots in the soybean half-plot and the primary roots were short with abundant secondary and some tertiary roots in the other half-plot. Root rot had been abundant on the soybeans in June but very little alfalfa root rot was noted in November. Pennscott red clover planted in August and treated in the same manner did not show a similar response of foliage and roots by November.

PASTURE RESEARCH AT STATE STATIONS

CONNECTICUT (STORRS)

Title: FALL CUTTING MANAGEMENT OF FORAGES

Leader: D. D. Wolf

The present study dealt with the influence of date of fall cutting on the yield and persistence of several forages. The data provided a recommendation of the critical date for fall harvest. Objectives were to determine the latest fall harvest date which will avoid loss in stand from winter killing and reduction in yields the following season, to evaluate several forages as to response to date of fall cutting, and to determine food reserve status of plants in each treatment as correlated with survival and productivity.

Title: SPRING GROWTH AND DEVELOPMENT OF SEVERAL FORAGES

Leader: D. D. Wolf

Harvest schedules for perennial plants must be based on the ability to recover or regrow rapidly. This ability is attained when the plant has matured enough to provide a high level of stored food and to develop a new system of buds for regrowth. Temperature, rainfall and past management are among the growth factors that may delay or encourage development of maturity. Research in areas outside the Northeast indicates that a guide to plant maturity is flower formation. If plant maturity is defined as ability to support rapid regrowth such as morphological development it may not be useful in all areas of the United States and in all seasons of the year.

Exploratory research indicated that food storage of spring alfalfa growth was at a high level before flowering was initiated. By this time well fertilized alfalfa had accumulated so much top growth that reduced light caused yellowing and shedding of lower leaves. As the plant developed to the flowering stage little additional digestible dry matter accumulated since new leaves developing at the top just replaced the lower leaves as they dropped. Food storage as related to flowering followed the classic trends during regrowth of second and third harvests.

Management may not be difficult with late cuttings because late stages appear at nearly the same dates each year. If we stress early cutting by calendar date without regard to the development of the plant or type of growing conditions, we may find unexplained injuries to forage stands in some

years. Balancing calendar date and stage of maturity as criteria for cutting is important with legumes. In general, nutritive value has been found to be more closely related to stage of growth than to date of cutting. If this is confirmed we should begin to stress the importance of plant maturity in forage evaluation and management.

Title: GRASS VARIETY TEST

Leader: D. D. Wolf

A wide range of maturity dates gives opportunity to plan for harvest schedules. About 2 weeks difference exists between early and late maturing timothy varieties as well as orchardgrass varieties. The advantage of early maturing varieties is in the greater yields of regrowth.

Observations of soil moisture showed that the top 12 inches under grass were depleted most of the season but under alfalfa some soil moisture remained at 6 inches and throughout the soil profile. Thus alfalfa had moisture to support feeder roots in the surface soil layers. A soil test indicated that all P and K fertilizers applied were in the top layer and not available to plants under dry soil conditions.

Alfalfa was superior to grasses in total yields during a season with a drought stress. Clair timothy and Kentucky 31 tall fescue were superior varieties within these species. Little difference existed among brome grass or reed canarygrass varieties. Late maturing varieties of orchardgrass may be better suited to hay and legume-grass mixtures, while early maturing varieties are better suited for pasture. Under the fertilization provided timothy yielded more than other grasses.

Title: ESTABLISHMENT OF LEGUME-GRASS MIXTURES

Leader: D. D. Wolf

Legume-grass mixtures have numerous advantages over pure stands for production of hay or for use as pasture. Establishment and maintenance of such mixtures require excellent management and selection of compatible species. In order to find a seeding method that will result in a successful stand of mixtures, the grass and alfalfa were planted in alternate rows. In this way little competition for space would occur during the initial growth following defoliation.

It was noted that each species of grass may have a most desirable row combination for high yields of hay with nearly equal proportions of legume and grass. Planting reed canarygrass in rows appeared to have an advantage

over broadcast plantings. Bromegrass was nearly eliminated from all mixtures during the first season, probably because each harvest was made at a time unfavorable to the bromegrass.

Title: TRENDS AND DISTRIBUTION OF HYDROCYANIC ACID CONTENT IN
FORAGE SORGHUMS (SORGHUM VULGARE PERS.)

Leaders: D. D. Wolf, W. W. Washko, L. Barber, and R. A. Peters

Varieties differ greatly in HCN content particularly when plant heights are greater than 24 inches. Varieties with sudangrass parentage have lower HCN than those with sorghum parentage.

HCN content of the total plant was largely influenced by the proportion of low HCN-containing stems, sheaths, and mid ribs. Leaf blade disc samples indicated a basis for management recommendations if plants were pastured but the dilution by stems should be considered when recommending green chop usage. Safe grazing time was indicated to be when the stem is one-half the height of the total plant, but further study is needed to establish this relationship.

While leaves of plants may be much higher than stalks, a grazing animal may feed almost entirely on the palatable leaves if given free choice. Animals vary in their tolerance to the poison. A small quantity of forage containing a high amount of poison may be consumed safely. Generally, the best policy would be to select a level that would not injure the most sensitive animal if it consumed a complete fill of the forage that contained a high level of the poison.

Title: DATE OF FERTILIZER APPLICATION FOR FORAGES

Leader: L. Barber

Yields of grasses were increased by application of 240 lb K_2O as compared with 180 lb per acre K_2O but no difference occurred with alfalfa. Lowest grass yields resulted from January application but the cause cannot be assigned to nitrogen or potassium because of the experimental design.

Weather conditions caused abnormal growth and the results cannot be considered conclusive. If moisture was limiting growth full benefit from the spring-applied nitrogen would not result. Thus if a portion of the fall- and winter-applied nitrogen was lost there would still be enough remaining to provide all the yield potential obtainable from the available moisture.

Yields of alfalfa reflect the influence of potassium application since no nitrogen was applied. Yields appeared to be greater from spring than from early fall applications.

Title: THREE-YEAR ASSESSMENT OF THE CONTINUED USE OF ATRAZINE
ON CORN IN A ROTATION OF CORN-OATS-ALFALFA

Leader: R. A. Peters

No injury of spring seedings of oats or alfalfa were observed on a fine sandy loam soil in 3 successive years following corn treated with 2 lb ai/acre of atrazine. The rainfall was less than 80% of normal each of the 3 years. One series of plots received 2 lb on corn each year or a total of 6 for the 3-year period without indication of injury.

The response from 4-lb treatments varied. No injury to oats or alfalfa was observed in 1963 on plots first treated with 4 lb in 1962. However, in both 1964 and 1965, injury to both oats and alfalfa could be seen. Injury was also quite evident in 1965 on plots receiving 8 lb atrazine in 1964.

Title: EVALUATION OF HERBICIDES FOR WEED CONTROL
IN NEW SEEDINGS OF ALFALFA

Leader: R. A. Peters

Most chemicals were selective on alfalfa. Ioxynil, however, caused severe injury. The injury was evident within a few hours of spraying with scorching and necrosis of leaves and stems. Early stunting was observed from treflan at 1 lb per acre and some stand reduction from CP 31393 (Ramrod) at 4 lb per acre.

Wild radish was not controlled as readily as other broadleaf weeds by most chemicals, either pre- or postemergence. The outstanding material for wild radich control was oxyinol and bromoxynil.

The only treatments giving both adequate broadleaf and grassy weed control were with EPTC. The failure of the combination of 2,4-DB and dalapon to give good control was related to the ineffectiveness of 2,4-DB on wild radish and the relatively advanced stage of the grasses in respect to dalapon.

Excellent grass control was obtained from the following treatments: EPTC, D-263, benefin, treflan, betasan and CP 31393. Dacthal gave fair control. Since so few of the materials gave adequate control of both broadleaf and annual grasses, combinations of materials should be given more emphasis in future research. The importance of timing of application was shown again in this experiment by the poor results obtained from dalapon. Variation

between species in sensitivity was clearly demonstrated by the poor control of wild radish with several chemicals which gave adequate pigweed and lambsquarter control.

DELAWARE

Title: THE RELATIVE IMPORTANCE OF FALL-LAID AND SPRING-LAID EGGS
OF THE ALFALFA WEEVIL

Leaders: P. P. Burbutis and D. F. Bray

The 1964-65 field studies, employing cages but depending upon natural egg deposition, confirmed our previous findings that injury to alfalfa per larva at the average time of first cutting (circa May 20) was highest in those treatments containing all or nearly all fall-laid eggs. These data indicated that approximately 60% of the total feeding injury at the time of first cutting can be caused by larvae originating from fall-laid eggs. The injury occurring to alfalfa in northern Delaware appears to be related to a combination of factors, including population size, survival rate of larvae and overwintering eggs, cutting time, and especially to the stage of weevil development at the time of first cutting.

Title: ALFALFA WEEVIL-BIOLOGICAL CONTROL

Leaders: P. P. Burbutis and D. F. Bray

In cooperation with the Biological Control Section, ARS, USDA, at Moorestown, N. J., 9 releases of parasites were made in 1 section of northern Delaware from April 14 to June 1, 1965. Approximately 485 adults of Microctonus aethiops and 163 adults of Bathyplectes anurus were released during this last season.

Title: ALFALFA WEEVIL CONTROL AND FLAME CULTIVATION
(COOPERATIVE TEST WITH UNIVERSITY OF MARYLAND)

Leaders: P. P. Burbutis, A. L. Steinhauer, and W. L. Harris

Treatments were applied on April 5, 1965. The best treatment, flaming at 1.5 mph, gave fairly good initial reduction of adults (84%) and an egg population 76% less than in the check plot. Four days prior (May 11) to first cutting, larval populations were much lower (83% and 88% reduction)

in the flamed plots as compared to the check and feeding injury was correspondingly much lower. Control did not extend beyond the first cutting and under practical conditions the stubble and/or the young second growth should have been sprayed.

Some phytotoxicity was noted in this test. When plants were examined on April 29, 24 days subsequent to flaming, the check plants averaged 2 inches taller as compared to the plants in the flamed plots. However, no height differences were noted at the time of first cutting.

Pea aphid populations were considerably lower in the flamed plots (1.5 mph = 87% reduction) as compared with the check.

Title: EVALUATION OF CHEMICAL TREATMENTS FOR
ALFALFA WEEVIL CONTROL

Leader: W. A. Connell

Sprays of methoxychlor at 1 lb with Diazinon at 0.4 lb or malathion at 0.5 lb per acre applied May 11 gave commercial control of the weevil in experimental plots. Three experimental chemicals were not effective.

MAINE

Title: ALFALFA SEEDING RATE ON GRASS ESTABLISHMENT

Leaders: R. F. Stafford and C. S. Brown

An early May seeding was made to study the effect of plant population of Narragansett alfalfa on establishment and productivity of associated grasses in the seeding year. The grasses studied, each sown at a single rate in simple mixtures with alfalfa, were Saratoga brome, Pennlate orchard, Climax timothy, and reed canary. Alfalfa was sown at 0, 2, 4, 8, 16 lb per acre with each of the grasses.

The experiment was conducted at a high level of mineral nutrition. To allow full expression of the grass component, an unusually high level of applied nitrogen was used, 60 lb N at seeding on May 5 and 100 lb N after first harvest on July 19. A second harvest was made on August 30.

Alfalfa yields increased with increasing seeding rate, ranging from 1.3 tons dry matter at 2 lb per acre to 2.7 tons at 16 lb per acre. Grass establishment and yields were inversely related to alfalfa population. Average dry matter yields of grasses for the 4 species, ranged from 2.0 tons in the check

plots sown without alfalfa to 0.4 tons at the 16-lb rate of alfalfa. Orchardgrass proved most tolerant and timothy least tolerant of alfalfa competition. However, even the orchardgrass showed marked suppression at high rates of alfalfa, with yields ranging from 2.5 tons without alfalfa to 0.5 tons when sown with 16 lb alfalfa seed.

Title: SOIL TEMPERATURE AND ESTABLISHMENT OF
SUMMER ANNUAL FORAGES

Leaders: A. J. Gay and C. S. Brown

The effect of soil temperature on germination and seedling emergence of summer annuals was studied in growth chamber and field experiments. Seedling emergence was completely inhibited for all species studied (millet, sudangrasses, sudan-sorghum hybrids) at soil temperatures below about 50°F, and relatively slow at temperatures between 50 and 60°F. However, a fairly high percentage of seeds commercially treated was able to survive several weeks exposure in cold soils and produce normal seedlings when soil temperature rose to higher levels.

The field experiment indicated a large loss in potential yield from delaying the seeding until a mid-June date (conventional for this area). The following yields of dry matter were obtained in two cuts, averaged for all species and seeding rates: 3.8 tons from May 4 seeding; 4.1 tons from May 25 seeding; 2.9 tons from June 15 seeding.

Title: PLANT-SOIL-ANIMAL INTERRELATIONSHIPS IN
PHOSPHORUS METABOLISM

Leaders: W. P. Apgar, B. R. Poulton and C. S. Brown

Climax timothy plots designated as low-P, medium-P and high-P forages were fertilized with 0, 300 and 1200 lb of P₂O₅ per acre prior to seeding in August 1963. Drought conditions resulted in poor establishment of the low-P plots and 1964 hay harvest was delayed until the full-bloom stage to avoid possible injury to the low-P plots from an early cut. Average phosphorus concentrations of the 1964 forages were: low-P, 0.19%; medium-P, 0.22%; and high-P, 0.24%. This range was considered too narrow to give significant results regarding the effects of phosphorus level on relative intake and nutritive value of these forages for ruminants.

In order to increase the range of phosphorus concentration in the forages, the high-P plots were fertilized with an additional 350 lb of P₂O₅ per acre in May 1965. The average levels of phosphorus in the 1965 hays harvested at the boot stage were: low-P, 0.21%; medium-P, 0.24%; and high-P, 0.35%. Winter feeding trials with sheep were conducted using the low-P and high-P

forages along with a treatment consisting of the low-P forage supplemented with monosodium phosphate in amounts to make the phosphorus intake equal to that on the high-P forage. Phosphorus and calcium balance as well as digestibility analyses are in progress. Average ad libitum intake was similar for the low-P, high-P and supplemented low-P forages.

MARYLAND

Title: RED CLOVER BREEDING INVESTIGATIONS

Leader: E. H. Beyer

Prior to initiation of a program of interspecific hybridization, 68 species of Trifolium were studied. Seedling characteristics were recorded, self compatibility estimated, and chromosome number determined for 22 Trifolium species for which no previous records could be found in the literature.

Title: FORAGE CROP VARIETY EVALUATION IN MARYLAND

Leaders: W. J. Moline, E. H. Beyer, N. A. Clark, and A. M. Decker

Eight varieties of birdsfoot trefoil planted in the fall of 1960 and in the spring of 1961 are being evaluated for persistence. These are uniformly clipped throughout the summer to simulate pasture conditions. The persistence of the Northeastern varieties has been superior to that of other varieties.

Data were collected on 28 alfalfa varieties at the Dairy-Forage Research Farm, Clarksville, Maryland, and on 20 varieties at the Hopkins Farm, Fairland, Maryland. Results from these data and other trials, in past years, support the recommendation of Cayuga and Saranac.

Title: SOD SEEDING ESTABLISHMENT STUDIES

Leader: A. M. Decker

Four harvests were taken on the Midland sod-seeding study to measure residual treatment effects from the past 3 years (1964 Annual Report, p. 38). Yields range from 1.78 tons dry matter per acre with 200 lb N per acre (with or without sod-seeded rye) to 6.41 tons with 800 lb N on the Midland and 40 on the sod-seeded rye. The addition of N to the sod-seeded crop affected the

residual nitrogen available at 400 and 800 lb N per acre on the Midland but not at the 200-lb rate. There was no increased production from residual nitrogen on plots with hairy vetch at the 200-, 400-, or 800-lb nitrogen rates. In fact the yields for the Midland-rye-hairy vetch treatment at the 800-lb nitrogen rate were only half that where the vetch was left out.

Birdsfoot trefoil and crownvetch were seeded into an old bluegrass pasture using different techniques of sod-seeding. The performance of these 2 species was compared with nitrogen fertilization of the existing bluegrass sward and with complete renovation to an orchardgrass-red clover-ladino clover mixture. Crownvetch appears to be better adapted to sod-seeding than trefoil. To date neither has been as productive as complete renovation or nitrogen fertilization.

Title: DIFFERENTIAL HARVESTING MANAGEMENT OF RED CLOVER AND RED CLOVER-TIMOTHY STANDS UNDER THREE LEVELS OF FERTILIZATION

Leader: A. M. Decker and L. R. Wade

All treatments of the initial experiment (1964 Annual Report, p. 39) were harvested at the early bloom stage to measure residual treatment effects. Yields were good on all treatments. The data, however, were not too usable because of extensive grazing by deer. Although stands were good in most plots following the first harvest of the second full harvest year, most plants died before the second harvest, regardless of fertilizer treatment, harvest management, or time of seeding.

A second planting of the experiment was harvested for the first year during the 1965 growing season. Total yields were about the same regardless of fertility level or harvest stage. The main difference found at the two locations was a difference in clover and grass establishment. Because of the extremely dry summer and fall of 1964, only red clover survived the spring seeding, while the timothy was much stronger than the clover with the fall seeding.

Title: EFFECT OF DIFFERENTIAL FERTILIZATION ON FORAGE PRODUCTION AND CHEMICAL COMPOSITION OF RED CLOVER

Leaders: C. B. Kresge

Chesapeake red clover was overseeded on the experimental area in February, 1965. Inadequate moisture during the preceding fall had caused a poor stand of fall-seeded clover. A good stand was obtained and the red clover became well established during 1965. No yield measurements were taken. Differential amounts of P and K were applied in November, 1965. Fertilizer was applied at several rates of the following phosphate to potash ratios:

1 to 1, 1 to 2, and 1 to 4. Potash rates are 0, 50, 100, 200, and 400 lb per acre.

Yields of red clover will be measured in 1966. Tissue samples of harvested forage from each plot at each cutting will be taken for determination of N, P, K, and acid-detergent fiber. Roots and crowns will be sampled at the end of the growing season in 1966 for determination of any effects of soil fertility on morphology and anatomy.

Title: EFFECT OF DIFFERENTIAL FERTILIZATION ON THE GROWTH AND DEVELOPMENT OF ALFALFA

Leaders: C. B. Kresge, V. A. Bandel, and M. G. Schnappinger

Root samples were taken from existing alfalfa root anatomy plots (1964 Annual Report, p. 43) on November 9, 1965. Some of the root samples taken on May 13, June 12, July 6, August 17, and October 19, 1964 were sectioned and examined under the microscope. The number of xylem vessels and the percent of root cross sectional area covered by xylem vessels (a reflection of the diameter size of xylem vessels) increased with K rate up to 40 or 50 lb of applied K per acre. However, at the 40-lb K rate about 80 lb of K were removed in harvested top growth in 1964. This means that the soil was contributing some K for plant use.

To eliminate this soil effect and to work with absolute amounts of K, a greenhouse experiment is being initiated in which alfalfa will be grown in sand culture. In some treatments P will be varied while in others K will be the variable.

Title: NUTRIENT BALANCE IN ORCHARDGRASS AS RELATED TO DIFFERENTIAL FERTILIZATION

Leaders: C. B. Kresge and V. A. Bandel

In 1965, 4 cuttings were taken from the orchardgrass experiment (1963 Annual Report, p. 41). Moisture was limiting but not quite so much as in 1964. The yields in 1965 were double those in 1964. Part of this was due to a large yield in the first cutting encouraged by a high rate of N applied in early spring. N additions per acre in 1965 were as follows: 115 lb on March 23; 43 lb on May 14, after the first cutting; 47 lb after the second cutting; and 65 lb on September 2.

The grass had to be sprayed twice during the season with Sevin to control grasshoppers. This is the first time in the duration of the experiment that serious damage from grasshoppers occurred.

Yield responses to P, K, and Mg were obtained in 1965. Optimum rates of these 3 nutrients for 4 tons of orchardgrass appear to be about 40 lb of P,

between 160 and 240 lb of K, and 40 lb of Mg per acre. With these and higher yields, consideration should be given to split applications of K to avoid excess luxury consumption and subsequent late summer K deficiency.

Plant tissue analyses for N, P, K, Ca, and Mg on the 1964 and part of the 1965 harvests have been completed. These data have yet to be fully evaluated before any conclusions can be drawn.

Title: RESPONSE OF MIDLAND BERMUDAGRASS TO TWO SOURCES OF NITROGEN,
THREE RATES OF NITROGEN, AND THREE LEVELS OF LIME

Leaders: A. M. Decker and J. H. Axley

No nitrogen or lime was applied to experimental treatments in 1965. Four harvests were made during the growing season to measure residual treatment effects (1964 Annual Report, p. 38). The effects of residual nitrogen on forage yields were significant through the growing season. It will be necessary to harvest these plots more than 1 year without nitrogen fertilization in order to fully measure nitrogen carry-over. Total forage yields ranged from 1.04 tons dry matter per acre with no nitrogen and no lime to 6.61 tons with 1800 lb N as NH_4NO_3 plus lime to counteract acidity. Twice the amount of lime did not improve yields. Without added lime, 1800 lb of nitrogen as $(\text{NH}_4)_2\text{SO}_4$ was only half as productive as the same rate of NH_4NO_3 . With lime, however, the 2 nitrogen sources were about equal. At 200 and 600 lb of N per acre, the addition of lime had little effect on residual yields. There was a small(nonsignificant) decrease with the high lime application.

Title: NUTRIENT REQUIREMENTS OF SUMMER ANNUALS FOR FORAGE

Leaders: C. B. Kresge and I. R. Thomas

A greenhouse experiment was initiated and partially completed and a field study was carried through 1 year. The greenhouse experiment dealt with the N requirements of Sudax: a forage sorghum-sudangrass hybrid. The field investigation included differential N, P, and K fertilization. In the greenhouse, Sudax responded significantly to 160 lb of N per acre, yielding 6.24 tons of dry matter per acre. Yields at 120 and 0 lb of N were 5.33 and 4.09 tons per acre, respectively. There were no advantages to split applications of N. First year yield data from the field experiment showed no response to differential N, P, or K treatments except for a positive increase when the N rate was increased from 0 to 100 lb per acre.

Title: AGRICULTURAL WASTE WATER ACCOMMODATION AND
 UTILIZATION BY VARIOUS FORAGES

Leaders: C. B. Kresge, T. J. Wiggins, and R. L. Green

Differential amounts of waste water from a chicken packing processing plant will be applied with a sprinkler irrigation system to several forage species. Forages to be compared have been seeded and include pure stands of Kentucky 31 tall fescue, reed canarygrass, and orchardgrass; a mixture of the above grasses; and a mixture of alsike clover, ladino clover, and tall fescue. A fallow plot will be included. The forages will be harvested several times each year and evaluated for yield and content of N, P, K, and possible waste contaminants. Plant vigor and persistence will be observed. The infiltration rate with which the water enters the soil under the different treatments will be measured. The soil will be analyzed biennially for pH, P, K, organic matter, and soluble salts.

Title: CROPPING SYSTEMS FOR DAIRY FARMS: A STUDY OF THE GROWTH
 RESPONSES OF CORN AND ALFALFA TO SOIL FERTILITY AND IRRIGATION

Leaders: N. A. Clark and C. B. Kresge

Four cropping systems are being compared under several levels of soil fertility at 2 different locations. The cropping systems are: alfalfa hay, corn silage, corn silage plus wheat-vetch cover crop, and corn grain. Fertilizer rates range from 1/2 through 2 times the recommended rates determined according to soil tests. Irrigation is included at the Forage Research Farm location. The objective is to obtain and compare maximum yields of all crops included by eliminating as many limiting factors as possible at each location.

At the Plant Research Farm in 1965, maximum dry matter yields of wheat-vetch silage and corn silage, alfalfa hay, and corn silage were 4.2 + 3.4, 4.1, and 5.0 tons per acre, respectively. Maximum corn grain yield was 110 bushels per acre. At the Forage Research Farm, there was less response to fertilizer than at the Plant Research Farm, probably because of the higher inherent soil fertility at the Forage Farm. Irrigation substantially increased yields of corn grain and corn silage after wheat-vetch. Maximum yields at the Forage Research Farm for wheat-vetch plus corn silage, alfalfa, and corn silage were 3.0 + 8.1, 5.9, and 8.8 tons of dry matter per acre, respectively. Maximum corn grain yield was 173 bushels per acre.

Title: THE EVALUATION OF SUMMER ANNUAL PASTURES FOR LACTATING DAIRY COWS

Leaders: N. A. Clark, R. W. Hemken, and J. H. Vandersall

Piper sudangrass and Gahi No. 1 pearl millet, grown on soil on which 2 tons of lime and 300 lb of K_2O per acre were applied, were compared with pearl millet grown without the addition of lime and potassium. One hundred pounds each of nitrogen and P_2O_5 per acre were applied to the entire area. Forage from the 2 pearl millet treatments and the 1 sudangrass treatment was green-chopped daily and fed to 3 groups of milking cows.

Milk production remained normal for all 3 groups of cows. Butterfat also remained normal for cows fed sudangrass and cows fed pearl millet from soil to which no lime or potassium was added. Butterfat was significantly lowered, however, in cows fed pearl millet grown on the soil to which lime and potassium were added.

Title: PASTURE EVALUATION USING BEEF STEERS

Leader: A. M. Decker

Grazing of experimental pastures (sod-seeded rye in Midland bermudagrass with 2 levels of nitrogen fertilization and test animals with no grain or with 0.7 lb grain per 100 lb body weight) was started March 26 and terminated October 27, 1965. Test animals were uniformly wintered before being divided into uniform groups, based on total weight and winter gains, and randomly assigned to experimental treatments. Although analysis of data has not been completed, general observations can be made. Carrying capacity and beef production per acre were increased with higher nitrogen fertilization and with grain feeding. The slaughter grade of animals on all pastures was increased approximately 2.0 points by feeding grain.

Title: HOST PREFERENCES OF ALFALFA WEEVIL IN RELATION TO PLANT PRODUCED ATTRACTANTS AND REPELLENTS

Leaders: A. L. Steinhauer, H. D. Byrne, R. E. Menzer, and C. C. Blickenstaff (USDA)

Crude alfalfa steam distillate extracts of alfalfa were separated on thin layer chromatography with chloroform:hexane (7.3) into 6 fractions. Two fractions were attractive to alfalfa weevil adults. Relatively large quantities of these 2 fractions are being accumulated in attempts to identify and purify the attractive components.

Title: APPLICATION OF ENERGY FOR CONTROL OF INSECTS

Leaders: W. L. Harris, A. L. Steinhauer, N. A. Clark, and
C. C. Blickenstaff (USDA)

The use of broadcast flame cultivators for the control of alfalfa weevil was evaluated. The only time alfalfa can be treated effectively for weevil control is during the dormant season. The control obtained approaches that obtainable with current pesticides. There seems to be some added benefit of weed control, but this needs added work. Continuing work on this project is planned for next year.

Title: BIOLOGY AND CONTROL OF ALFALFA WEEVIL

Leaders: A. L. Steinhauer, J. Neal, and C. C. Blickenstaff (USDA)

There have been no significant new developments relative to chemical control of the alfalfa weevil. Recent work has served to confirm the importance of proper timing of applications of chemicals for control of larvae. Current work on this project centers around the effect of approved chemicals on beneficial insects in alfalfa (i.e., parasites, predators).

MASSACHUSETTS

Title: FACTORS INFLUENCING THE SOLUBLE CARBOHYDRATE RESERVES IN
ORCHARDGRASS

Leaders: W. G. Colby, M. Drake, H. Oohara, and N. Yoshida

The evidence seems clear that carbohydrate reserves play an important and vital role in the growth and performance of orchardgrass. It is further evident that heavy applications of nitrogen may reduce carbohydrate reserves to critically low levels during periods of dry, hot weather, resulting in poor plant growth and serious injury to many plants and even destruction of the stand. Liberal amounts of nitrogen may be applied in early spring when the weather is cool and normally moist, but later in the season, especially if the weather is hot and dry, the use of nitrogen must be restricted, if not discontinued altogether. Irrigation is helpful but is not a substitute for rain and cooler weather.

As a result of cooperative work with Dr. H. Oohara and Dr. N. Yoshida at the Obihiro University, Obihiro, Hokkaido, Japan, we have been able to demonstrate conclusively that carbohydrate reserves in cool season grasses build up progressively throughout most of the growing season under cool moist growing conditions, even at high levels of nitrogen fertilization. There is no doubt that temperature and moisture, as well as nitrogen fertilization, are closely associated with carbohydrate reserves in cool season grasses.

We have shown that height of cut is also an important factor but are inclined to believe that at least part of the greater injury with closely cut orchardgrass (1.5 in. vs 3 in.) is due to higher soil temperatures which develop on closely clipped plots. The stage of growth at first cutting has also been shown to be a factor at Amherst. But here again, we believe a soil temperature relationship is involved. Early cut orchardgrass recovers and provides a good ground cover before normally high temperatures develop. Orchardgrass cut at a later growth stage exposes the soil to normally higher temperatures and greater injury results. At another location, time of cutting at first harvest may have no effect whatsoever.

Work with other cool season grasses indicates that the performance of orchardgrass is characteristic not only of this grass but of all other cool season grasses. We think this is why they are cool season grasses.

Title: INVESTIGATIONS OF FORAGE CROP INSECTS IN
MASSACHUSETTS IN 1965

Leaders: F. R. Shaw, R. A. Callahan, M. C. Miller, and F. R. Holbrook

I. Abundance and seasonal distribution—As one phase of the investigations of forage crop insects in Massachusetts, extensive collections were made in Berkshire, Hampden and Hampshire Counties.

In 1965, the most abundant single species was alfalfa weevil (Hypera postica). A maximum of 4,100 per 100 sweeps was obtained, this being the largest number ever collected in the State. Untreated fields had from moderate to severe damage, with many exhibiting the "frosted" appearance associated with the injury from this insect. The first specimens were taken on May 5.

Pea aphid (Acyrtosiphon pisum) was remarkably low in numbers, comprising only 2.6% of the total. In previous years, this pest has been much more numerous, representing from 45 to 60% of all insects. Beneficial insects including lady beetles, damsel bugs, lacewings and syrphids, were also less abundant. Plant bugs were somewhat less abundant in 1965 comprising 3.81% of the total, whereas in 1964 they represented 4.36%. Tarnished plant bug (Lygus lineolaris), as in previous years, was most common, with meadow plant bug (Leptopterna dolabratus) and alfalfa plant bug (Adelphocoris lineolatus) ranking second and third. Leafhoppers represented 4.43% of the total (5.81% in 1964). Errastunus ocellaris was the most common species collected, representing 50% of the total. Clover leafhopper (Aceratogallia sanguinolenta) ranked second, and potato leafhopper (Empoasca fabae) third.

The latter species was first observed in Southwick on May 6. It was more abundant than in 1964 and some fields showed considerable yellowing. Meadow spittlebug (Philaenus spumarius) was slightly more abundant in 1965, representing 0.72% in comparison to 0.33 in 1964. In some fields in southern Berkshire County considerable stunting of plants was noted.

A summary of the result of the survey is presented in the following table. This report is based on collections of 46,324 insects taken from April 15 through June 15. Sampling was done by taking 100 sweeps with a 15-inch net in each field at approximately weekly intervals. The same fields were examined each week.

Table 1. Abundance of forage crop insects in western Massachusetts, spring 1965.

Insect name or group	Percent	
	Of group	Of total
Aphids:		
<u>Acyrtosiphon pisum</u>	100	2.60
Plant bugs:		3.81
<u>Lygus lineolaris</u>	61.00	
<u>Leptopterna dolabratus</u>	15.24	
<u>Adelphocoris lineolatus</u>	12.02	
<u>Trigonotylus ruficornis</u>	5.08	
<u>Amblytulus nasutus</u>	4.80	
Others	2.48	
Leafhoppers:		4.43
<u>Errastunus ocellaris</u>	50.02	
<u>Aceratogallia sanguinolenta</u>	19.94	
<u>Empoasca fabae</u>	8.05	
<u>Endria inimica</u>	6.50	
<u>Macrosteles fascifrons</u>	4.70	
<u>Doratura stylata</u>	2.33	
<u>Draeculacephala</u> spp.	2.13	
Others	2.35	
Beetles:		84.94
<u>Hypera postica</u>	98.99	
Elaterids	0.49	
<u>Sitona hispidula</u>	0.24	
<u>Hypera punctata</u>	0.11	
Others	0.17	
Meadow spittlebug (<u>Philaenus spumarius</u>)		0.72

Table 1 (Cont'd)

Insect name or group	Percent	
	Of group	Of total
Lepidoptera:		0.37
Noctuids	33.53	
Geometrids	26.59	
Others	39.88	
Miscellaneous insects:		
Sawflies		0.33
Grasshoppers		0.10
Membracids		0.02
Others		0.89
Beneficial insects		0.58
<u>Nabis ferus</u>	32.08	
Coccinellids (lady beetles)	26.87	
Anthocorids	22.39	
Chrysopids	14.55	
Reduviids	4.10	
Related beneficial Arthropods:		
Spiders		0.83
Harvestmen		0.38

Observations were made concerning the overwintering of eggs. Our data indicate that this method of overwintering was of slight importance in maintaining alfalfa weevil populations during the 1964-65 seasons.

II. Biological control—In cooperation with Dr. Carl Blickenstaff, Entomology Research Division, ARS, we made larval collections in Hampshire and Franklin counties. Blickenstaff determined that there was from 0 to 55% parasitism of these larvae by Bathyplectes curculionis and 0 to 64% by Tetrastichus incertus. We continued the investigations during the remainder of the season and found T. incertus to be common in western Massachusetts. Parasitism was as high as 90% with an overall of 64%. Parasitized larvae were found in late September. No observations were made in eastern Massachusetts.

III. Chemical control—In 1965 we conducted 2 experiments to evaluate pesticides for the control of the alfalfa weevil. In each experiment, the plots were randomly arranged in 3 blocks. Applications were made by compressed air sprayers. Each treated plot received the diluted pesticide at the rate of 100 gal per acre. A more detailed description of the 2 experiments follows.

In the first experiment we applied SD 7438 at 1.0 and 2.0 lb actual per acre and SD 9129 at 1.0 lb actual per acre as pregrowth treatments on April 13. On April 27 we repeated the applications. Height of the alfalfa on April 27 averaged 3.7 inches.

Collections of 50 sweeps per plot were made using a 15-inch net on May 10, 16, 24 and June 1. The data were analyzed by analysis of variance. The means were compared at the 5% level using Duncan's Multiple Range Test.

Results — May 10. No significant difference between control plots and those treated with insecticides.

May 16. SD 7438 at 2 lb actual per acre was significantly better than the other treatments which in turn were superior to the control plots.

May 24. No significant differences between control and treated plots.

June 1. All insecticide treatments significantly better than control but no difference between treatments.

Stubble treatments following first cutting—On June 16 we laid out 3 blocks each containing 12 plots randomly arranged. The materials, formulations and amount applied per acre appear in Table 2.

Collections were made with a 15-inch net using 50 sweeps per plot on June 23, 30, July 7 and July 14. The data were examined by analysis of variance and the means were compared using Duncan's Multiple Range Test.

Results — June 23. SD 9129, Niagara 10242, Agway Alfalfa Spray, Alfatox and Methyl Ethyl Guthion were significantly better than the other treatments at the 5% level. At the 1% level there was no difference between treatments.

June 30. No differences were observed between the treatments and control at either the 1% or the 5% levels.

July 7. Niagara 10242 and Methyl Ethyl Guthion were significantly better than the other treatments at the 5% level. No difference was found at the 1% level.

July 14. Methyl Ethyl Guthion, Niagara 10242, Bidrin, Imidan, Thiocron and Agway Alfalfa Spray were significantly better than the other treatments at the 5% level. At the 1% level only Methyl Ethyl Guthion was significantly better than the other treatments.

IV. Residue studies—Rates of disappearance of Bidrin from green and field dried alfalfa were determined. When analyses are completed, we will also have disappearance curves of SD 9129, Chipman RP 11974, Niagara 10242 and Imidan from alfalfa.

Table 2. Insecticides evaluated as stubble treatments for alfalfa weevil control — 1965.

Manufacturer and material	Pounds per gallon of active insecticide in concentrate	Rate of application per acre
Agway Alfalfa Spray 22E	—	2 qts
Chemagro-methyl-ethyl Guthion	2	0.5 lb
Chipman-RP 11974	3	1.0 lb
Ciba-Thiocron	2.5	1.0 lb
Geigy-Alfatox	—	2 qts
Niagara 10242	50% WP	0.5 lb
Shell - Bidrin	9.0	1.0 lb
Shell - SD 7438	2.0	0.75 lb
Shell - SD 7438	2.0	1.0 lb
Shell - SD 9129	3.2	1.0 lb
Stauffer - Imidan	3.0	1.0 lb

NEW HAMPSHIRE

Title: BREEDING OF IMPROVED VARIETIES OF FORAGE SPECIES
ADAPTED TO THE NORTHEAST

Leaders: G. M. Dunn and L. J. Higgins

The 1963-65 average yields for 15 diallel single crosses in brome grass were 3.78 tons per acre in Syn 1 versus 3.41 in Syn 2. The crosses differed significantly for all years although much of the variance was due to generations. A few crosses showed little change from Syn 1 to Syn 2. This trial was repeated in a 1964 planting from which forage was harvested in 1965, but yields were reduced because of drought. Another test including 3-, 4-, 5- and 6-clone synthetics in Syn 1 and Syn 2 generations was established in 1965.

Clear-cut segregation occurred in seedling F_2 progenies for a "white" brome grass mutant (1964 Annual Report, p. 50), although expression varied with environment. Maximum expression occurred on short photoperiod at 60° F in the greenhouse. In the field, the mutant phenotype is expressed on mature plants only in the spring. Segregation to date indicates possible auto-tetraploid inheritance although there are still questions concerning the genetics of this chlorophyll mutant.

Seed was increased of New Hampshire red clover.

NEW JERSEY

Title: ALFALFA VARIETY TRIAL

Leader: C. H. Ramage

The trial was established in 1960. Included were Atlantic alfalfa, Maliani (an Italian import), and Orchies (a French variety). Yield results for 1961, 1962, 1963, 1964 and 1965 are summarized in Table 1. Three cuttings have been made each year.

Table 1. Alfalfa variety trial — dry matter yields.

Year	Atlantic lb/acre	Orchies lb/acre	Maliani lb/acre
1961	10,259	9,049	10,127
1962	8,935	8,535	7,917
1963	10,599	10,078	10,835
1964	9,567	8,534	8,490
1965	<u>9,409</u>	<u>8,076</u>	<u>8,836</u>
	48,769	44,272	46,205
Average	9,754	8,854	9,241

Title: SMUT DISEASES OF FORAGE GRASSES

Leaders: Philip M. Halisky and C. Reed Funk

Stripe smut caused by Ustilago striiformis is one of the most widespread and destructive diseases of pasture and forage grasses in the Northeast. This disease causes losses through the shredding and death of infected leaves and through reductions in seed yields. In New Jersey, Ustilago striiformis has been collected from Poa pratensis, Dactylis glomerata, Phleum pratense, Agropyron repens, Agrostis palustris, Agrostis alba, and Poa compressa. Holcus lanatus, which is known to be a host of stripe smut, was not infected.

Stripe smut is most prevalent and damaging in Kentucky bluegrass (Poa pratensis), especially in the variety "Merion." Nine selections and varieties of Poa pratensis were evaluated in field trials for their reaction to stripe smut infection. The test plots consisted of 6 replications which were arranged in a randomized, complete block design. The grasses were 5 years old (October 1965) when disease counts were made. The data in Table 2 show that none of the bluegrass entries was immune, 3 were resistant, 5 were susceptible, and 1 (Merion) was highly susceptible. At the present time selection and breeding for disease resistance appears to be the most promising method for controlling stripe smut in forage grasses.

Several other smut fungi (Ustilaginales) were found infecting pasture and forage grasses in New Jersey. They are listed below.

- a) Flag smut (Urocystis agropyri) was common on Agropyron repens but infrequent on Poa pratensis. In two instances plants were found with mixed infections consisting of both Urocystis agropyri and Ustilago striiformis in the same host plant.

- b) Kernel smut (Sphacelotheca sorghi) was present in "Black Amber" forage sorghum (Sorghum vulgare var. saccharatum). In one field 10.3% of the plants were smutted.
- c) Inflorescence smut (Ustilago syntherismae) was found occasionally in hairy crabgrass (Digitaria sanguinalis).
- d) Head smut (Sphacelotheca destruens) was widespread in witchgrass (Panicum capillare). This smut is commonly seen every year.
- e) An ovaricolous smut, Ustilago sphaerogena, was found occasionally in walters millet (Echinochloa walteri).

Table 2. Reaction of varieties and selections of Poa pratensis to infection by Ustilago striiformis in field plots at New Brunswick, N. J.

Variety of selection	No. smutted tillers per sq ft	Reaction
Dwarf ^a	1.1	Resistant
Park	4.2	Resistant
Pa. K5(47) ^b	4.7	Resistant
Pa. K1(51) ^b	17.6	Susceptible
Delta	20.0	Susceptible
Newport	37.0	Susceptible
Cougar	46.8	Susceptible
P-20	72.7	Susceptible
Merion	112.2	Highly susceptible
LSD at 5%	21.8	—

^aExperimental selection obtained from Purdue University.

^bExperimental selections obtained from The Pennsylvania State University.

Title: NITROGEN-POTASSIUM UTILIZATION BY THREE PASTURE GRASSES

Leader: R. W. Duell (B. Brooks Taylor)

Six pasture grasses were treated with (A) 2,000 lb 10-4.4-8.3 fertilizer per acre in a split application, (B) 200 lb per acre of N from NH_4NO_3 applied as above and (C) 1,000 lb per acre of 10-4.4-8.3 applied in a single application. Data are reported for 1960-61-62. Only tall fescue, orchardgrass, and Kentucky bluegrass survived with stand densities adequate for research purposes. Data are limited to these species.

The inadequacy of NH_4NO_3 as the only fertilizer was not apparent until well into the second year. In the third year decreased yields from NH_4NO_3 -treated plots were more pronounced. Tall fescue generally had a greater yield advantage over Kentucky bluegrass than did orchardgrass. Orchardgrass yields were more adversely affected by the NH_4NO_3 than were tall fescue or Kentucky bluegrass.

A sharp and consistent decrease in percent K in plant tissue was found at an early date where NH_4NO_3 was the only fertilizer. Orchardgrass was the most responsive and Kentucky bluegrass the least responsive to K supply. In both P content and responsiveness to P availability, the species ranked: orchardgrass, high; tall fescue, medium; and Kentucky bluegrass, low.

Forage plots receiving only NH_4NO_3 had consistently higher crude protein percentages. A second seasonal fertilizer application temporarily increased percent protein. Tall fescue generally had the lowest percent protein values.

During the winter of 1962-63, extensive winter killing of orchardgrass occurred in plots that received 200 lb of N per acre from NH_4NO_3 .

Title: SOIL AND PLANT RESPONSES TO LONG-TERM FERTILIZATION OF ALFALFA (*MEDICAGO SATIVA* L.)

Leaders: D. K. Markus and W. R. Battle

Alfalfa fertilization studies were conducted for 9 years (1952-1961) on Nixon loam at New Brunswick, N. J. The Atlantic variety of alfalfa and 5 rates of N and P and 6 rates of K fertilizer were used. Dry matter production, chemical composition, stand, and soil nutrient status were investigated.

Yields of forage were influenced only by the application of K fertilizer. At least 167 lb of K per acre per year was essential for maximum yields, which averaged about 4 tons of hay per acre for each of the 9 years.

A minimum of 167 lb of K was needed to maintain long-lived and productive stands. Applications of N induced infestations of grass and weeds. Applications of P also tended to reduce the stand of alfalfa.

High amounts of rainfall during the growing season resulted in a drastic and detrimental reduction of P content in alfalfa tissue and also in extensive but not detrimental reduction in the content of Ca and K (dilution effect).

Fertilization practices had no appreciable effect on the nitrogen content of alfalfa hay. Phosphorus concentration was increased by P and decreased by N and K fertilization. Potassium was increased by K and heavy N fertilization. A reduction of Mg content resulted from the application of P and K fertilizers. Calcium content was reduced by K fertilization.

The K obtained by the soil-supplying power (about 38 lb of K per acre per year) was insufficient for continued alfalfa production. Maximum yields were produced when about 80 to 160 lb of exchangeable K were present in the surface soil and at least 60 to 65 lb in the subsoil. Such desirable soil levels of K were maintained at the 167-lb rate of K fertilization. When less than 83 lb of K was applied, the initial levels of K were depleted in the surface soil, and when less than 167 lb of K was applied, the initial levels of K were depleted in the subsoil.

A considerable amount (about 17 lb per acre per year) of P was obtained from the soil-supplying power in the plots of the no-P treatment. Lack of crop yield response to application of P fertilizer was apparently due to this sufficiency of native P. On the other hand, a depletion in available soil P occurred in the plots where no P fertilizer was applied. This indicates that failure to apply fertilizer P cannot be practiced indefinitely without seriously affecting P fertility of the soil. There was a build-up of available soil P as a result of the annual application of more than 44 lb of this fertilizer.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF PERENNIAL FORAGE GRASSES

Leaders: J. L. Starling and R. W. Cleveland

Orchardgrass—Evaluation of a broadcast plot trial of 45 clonal progenies and check varieties was continued. Parental clones had been selected for disease resistance and lateness. Under natural conditions no marked difference of progenies in disease reaction has been noted. After 2 years' evaluation, certain clones are significantly higher yielding than best varieties.

A trial of new experimental synthetics established in 1964 was harvested. In first year of production the yields of synthetics were in same range as available varieties.

Two new polycross progeny trials were successfully established to evaluate 236 new clonal selections. A polycross trial was established to evaluate 23 medium late clones selected at the USDA Pasture Laboratory.

Seed from selected clones from a source nursery was harvested for continuation of study on relationship of rate of seed germination and maturity date of parent. Laboratory analyses of seed from a selection of clones of varying maturity showed excellent separation of maturity groups by percent of seed germinating at the end of 48 hours at temperatures between 20° C and 30° C.

Tall oatgrass--Plant introductions were studied for morphological variation and seed setting characteristics. Significant differences were found among strains in maturity date, seed yield, aftermath recovery rate and height. Self-fertility was found to be low in all lines, and was not related to open pollinated seed set.

Variety trials--Trials of orchardgrass, brome grass and timothy were harvested. New trials were established at two locations.

Title: THE GENETICS AND IMPROVEMENT OF PERENNIAL FORAGE LEGUMES

Leaders: R. W. Cleveland and J. L. Starling

Alfalfa

(1) Breeding of creeping-rooted alfalfa.--Intercross and self-pollination progenies were produced from vigorous creeping plants selected in 1964 from a nursery consisting of F_1 's of crosses between hay-type plants from adapted varieties and creeping-rooted plants with only moderate forage production potential. Plants which were creeping and high in forage production were selected. Progenies from similar selections made in 1963 were grown in 1964-65 in the greenhouse. Attempts to evaluate seedlings for creeping-rootedness in greenhouse plantings were unsuccessful. Greenhouse-grown progenies were transplanted to a field nursery for later rating. New intercrossing combinations of F_1 's previously selected are being carried out with greenhouse-grown plants. Progenies produced in 1964 through 1966 will be grown in field plantings in the next year. Progenies will be evaluated with the primary purpose of increasing the frequency of creeping plants in advanced generations.

(2) A polycross progeny trial carried out in cooperation with USDA was continued for the second year in 1965. This is an effort to evaluate general combining ability for forage yield and resistance to disease for 67 progenies. The results may make it possible to formulate new disease resistant varieties similar to Vernal in adaptation.

Variety trials

Forage yield and other characteristics of new varieties of alfalfa, red clover, and ladino clover were measured in field experiments at three Pennsylvania locations.

Title: CYTOGENETICS OF FORAGE CROP SPECIES
AND INTERSPECIFIC HYBRIDS

Leaders: R. W. Cleveland and J. L. Starling

Cytogenetic studies of diploid medicago

(A) Identification of existing trisomics.—Intercrosses of trisomics have been made, the families grown, and chromosome numbers of progenies identified in preparation for meiotic studies of $2n + 2$ plants. When intended studies of meiosis verify these plants as tetrasomics or double trisomics the parent trisomics can be identified. In only one cross out of two attempted has the desired $2n + 2$ plant occurred. Additional crosses will be made. Chromosome morphology studies of trisomic plants have been started for a different approach to the same problem. Pachytene chromosomes are to be studied and characterized in trisomics, diploid Medicago falcata and diploid M. sativa. A knowledge of the chromosomes of the two species is necessary before the chromosome morphology of the trisomics may be interpreted since many are of hybrid origin. Initial work has indicated some differences between the chromosomes of the two species.

(B) Production of new trisomics has been attempted by means of a progeny of a triploid plant from diploid M. sativa. Ten progenies have been produced and chromosome numbers will be verified.

(C) Two new genetic markers found in M. falcata introductions are floral characters and have been designated "red pedicel" and "spotted calyx." Progenies have been produced for genetic studies.

Species hybrids in Trifolium

Sesquidiploid hybrids have been produced from the cross $4 \times \underline{T. pratense} \times 2 \times \underline{T. pallidum}$. One hundred twenty hybrids were obtained and chromosome counts on 40 of these revealed a chromosome number of 22. The remainder of the hybrids have been identified on the basis of morphology. At present, attempts are being made to obtain hybrids using a less vigorous line of T. pallidum.

Title: MAINTENANCE FERTILIZATION OF GRASSLANDS
IN PENNSYLVANIA

Leader: L. F. Marriott

An established stand of alfalfa on soil of very high fertility was fertilized with N, P, K, B, and Mg. Yields were variable from 3.7 to 4.4 tons dry matter per acre with no consistent response for any element.

New stands of alfalfa and birdsfoot trefoil at the Southwestern Field Research Laboratory were fertilized with N, P, K, B, and Mg. In this first year of differential fertilization, there was no significant difference among yields from the various treatments. Adequate fertilization at seeding and lack of adequate moisture were at least partly responsible for this lack of differential response.

Title: PRODUCTIVITY OF N-FERTILIZED GRASSES

Leader: L. F. Marriott

Results from a 3-year study of N P K topdressing on timothy at the Southwestern Field Research Laboratory showed that with adequate PK, N increased yields to an average of 3.4 tons per acre from 1.4 tons with no N. The highest economical rate of N was 100 lb per acre in the spring plus 50 lb after the first cut. Yields indicated a need of 100 to 125 lb K_2O annually to avoid yield reduction. There was some indication that P applications were beginning to show a response in the third year.

September and October applications of 100 lb of N as NH_4NO_3 were nearly as effective as a normal spring application, but the mid-February application was slightly better than that made a month or more later.

Title: EVALUATION OF NEW FORAGE VARIETIES AND SPECIES
FOR DAIRY CATTLE

Leaders: J. B. Washko, W. L. McClellan, E. M. Kesler, and A. L. Haskins

Productivity of the various forage species in their 4th year of grazing was as follows: the Vernal alfalfa - Pennlate orchardgrass sward produced the highest yields of dry matter, 4.52 tons per acre, and provided the highest carrying capacity, 331 cow days per acre; next most productive was the Balbo rye and Suchow 34 sorghum-sudangrass hybrid in a double cropping sequence with 3.25 tons of dry matter and 325 cow days of grazing and the Viking birdsfoot trefoil - Pennlate orchardgrass mixture with 3.25 tons of dry

matter and 282 cow days of grazing; the nitrogen fertilized Pennlate orchard-grass sward produced 2.69 tons of dry forage per acre and 277 days of grazing; and last, the ladino clover - Pennlate orchardgrass combination with 2.37 tons of dry matter and 283 days of grazing.

When Penngift and Chemung varieties of crownvetch were subjected to grazing, the latter produced higher forage yields than the former whether grazed at beginning bloom or full bloom. Dairy cattle consumed crownvetch readily and no lack of palatability was noted.

The importance of including deep-rooted legumes such as alfalfa and birds-foot trefoil in forage programs during droughty years is emphasized by these data. This work also indicates that crownvetch, heretofore used primarily for special purpose plantings, has forage potential. Crownvetch thus offers farmers an alternative legume for forage until effective alfalfa weevil control materializes.

Title: UTILIZATION OF FORAGE BY BEEF CATTLE

Leaders: J. B. Washko, W. I. Thomas, P. J. Phillips, A. L. Haskins,
J. H. Ziegler, T. B. King, G. R. Kean, and G. A. Long

Alfalfa-orchardgrass swards were highest yielding, followed in order by reed canarygrass-birdsfoot trefoil, N-fertilized reed canarygrass and N-fertilized orchardgrass despite an early season drought. When two groups of crossbred Holstein-Angus cattle were grazed rotationally on these pastures, the 67 unbred heifer group gained 266 lb per acre per head and the 52 bred cows gained 200 lb per acre for the grazing season. In addition, 60 tons of surplus alfalfa-orchardgrass and trefoil-orchardgrass forage were removed for hay from 33 acres of pasture.

Also the performance of two crossbred cow-calf groups, stocked at 2 acres for cow with calf was compared on cropland pastures producing up to 3.14 tons of dry matter and on mountain pastures averaging 2.37 tons of dry matter per acre. On the cropland pastures 43 calves gained an average of 400 lb and their dams 217 lb or an average of 337 lb beef per acre per grazing season. On the mountain pastures 43 calves gained an average of 386 and their dams 179 lb or only 251 lb per acre. Calves on the mountain pastures consumed 2.25 lb per day more feed than cropland calves under creep feeding. Grass tetany, due to low Mg levels, was encountered on the mountain pastures which may have been responsible for the poor cattle performance. This research indicates the feasibility of producing crossbred dairy-beef in the state and that low magnesium levels on some Pennsylvania soils may limit animal productivity unless corrected by fertilization.

Title: EVALUATION OF SORGHUMS, SUDANGRASSES, AND
MILLETS FOR FEED PRODUCTION

Leaders: J. B. Washko, J. D. Harrington, and A. L. Haskins

Thirty-one varieties of summer annuals were compared for dry matter production at 4 locations, Landisville, Centre Hall, Ligonier and Bradford County in 1965. Three true sudangrass hybrids outyielded the standard open-pollinated variety, Piper, by 40.9%. The 25 sorghum-sudangrass hybrids outyielded the Piper variety by 84.2% and the true sudangrass hybrids by 30.7%. However, both the sudangrass hybrids and the sorghum-sudangrass hybrids were inferior to corn in dry matter production when harvested at the silage stage. Dry matter production for Pa. 602A hybrid corn harvested at the silage stage averaged 5.22 tons per acre and for 25 sorghum-sudan hybrids averaged 4.55 tons, state-wide.

Japanese millet produced the lowest forage yields of all the summer annuals tested. This millet produced more forage in Northern Pennsylvania than at the other locations in which it was tested.

No yield advantage was gained for the sudangrasses and sorghum-sudangrass hybrids when they were harvested at 4- and 6-inch stubble heights compared with a 2-inch stubble height cut. Both first harvest and aftermath yields were highest when harvests were made at the 2-inch stubble height.

Study of the influence of frost on prussic acid content of sudangrass and sorghum-sudan hybrids was continued in 1965. Eight varieties were evaluated for HCN content before and after frost. These varieties also were preserved in glass jars to simulate silage and were sampled for HCN 4, 6, and 8 weeks later. A total of 375 HCN determinations was made in 1965. Regardless of plant height at sampling, all varieties and hybrids increased in HCN after a killing frost. Higher HCN contents were obtained 24 hours after a killing frost. It took approximately two weeks after the first killing frost for the HCN level to drop back to that before frost. HCN levels were similar in the simulated silage samples when analyzed for HCN 4, 6, and 8 weeks after preservation. When samples were left uncovered at room temperature HCN content of the samples dropped, indicating volatilization.

Highest dry matter yields for corn silage were obtained when 40,000 plants were planted in two rows 7 inches apart on 40-inch centers. A 21.6% increase in dry matter production was obtained in favor of planting this population in double rows rather than in a single row in 1965.

Title: ESTABLISHMENT AND MAINTENANCE OF BIRDSFOOT TREFOIL

Leaders: J. B. Washko and E. R. Jones

Empire and Viking birdsfoot trefoil stands were subjected to 7 different cutting management treatments. The first harvest in 4 treatments was taken when (1) plants reached a 6-inch height with following harvests removed each time plants reached 6 inches, (2) 5 weeks after first harvest, (3) 6 weeks after first harvest, and (4) 7 weeks after first harvest. The remaining 3 treatments consisted of removal of the first harvest at half bloom with successive cuttings removed after 4 weeks and 6 weeks of growth.

Lowest forage yields for both varieties were obtained when the first harvest was removed at 6 inches and succeeding harvests on a 5-week schedule; highest forage yields when the first harvest was removed at 6 inches were obtained when succeeding cuttings were made after 7 weeks. The Empire variety was able to stand a 4-week cutting schedule provided the first harvest was not made until half bloom. Highest forage yields for both varieties were obtained when the first harvest was permitted to reach half bloom followed by a 6-week recovery period. The Viking variety was able to stand a 5-week cutting schedule but not a 4-week cutting when the first harvest was allowed to reach half bloom. Five terminal harvest dates, at 1-week intervals during September, also were incorporated in the clipping treatments. Plugs (210) from these and other treatments were taken when plants went into winter dormancy and placed in a dark growth chamber to measure carbohydrate reserves at dormancy via the etiolated regrowth technique.

An additional field experiment was initiated in mid-summer utilizing 16 seeding techniques. Band seeding and broadcast seeding with press wheels and various weights and fertilizer variables are being compared. Plant counts and carbohydrate reserves of the seedlings are being measured under the various treatments to determine the best method for establishment of mid-summer stands of birdsfoot trefoil.

RHODE ISLAND

Title: VIRUS DISEASES OF ALFALFA

Leader: W. C. Mueller

Two years' records on two field plots indicate no positive correlation between virus infection of alfalfa and longevity of stand.

Title: ROOT ROT OF ALFALFA

Leaders: H. W. Johnston and F. L. Howard

An antagonism developed on nutrient agar plates when Rhizobium meliloti was grown in association with Fusarium oxysporum, as shown by a flattening of the usually-aerial mycelium, and by inhibition of growth. Similarly, R. meliloti produced a growth inhibitor for F. roseum. However, nodulation did not develop normally when F. oxysporum was present previous to infestation of the alfalfa rhizosphere with Rhizobium, as demonstrated in vivo by use of the axenic Fahraeus culture technique. Regression of nodule development is a function of the prior duration of exposure of the alfalfa seedling to Fusarium. F. oxysporum alone initially stimulates seedling root growth significantly.

VERMONT

Title: STUDIES IN HYBRIDS OF LOTUS SPECIES

Leaders: A. Gershoy and F. Laing

Shake cultures and a variety of substrates are being used in a continuation of studies of very young embryos.

A seed increase is being made of a final selection of hybrids of 4 x L. tenuis crossed with L. corniculatus.

Title: FORAGE CROP INSECTS, THEIR RELATIVE
IMPORTANCE AND CONTROL

Leader: George B. MacCollom

The alfalfa weevil, Hypera postica Gyll., continued northward movement during 1965 (1964 Annual Report, p. 63). Infestations were found throughout Champlain Valley to the Canadian border. Releases of Tetrastichus incertus, Bothyplectes curculionis and Microtonus aethiops were made in cooperation with USDA. No recoveries were made from collection in the fall of 1965. Chemical control experiments did not result in significant yield differences because of the prevailing drought conditions.

Title: FORAGE CROP VARIETY TRIALS

Leader: G. M. Wood

First year yield data were obtained for alfalfa, timothy, and orchardgrass in variety trials previously reported (1964 Annual Report, p. 63). In spite of the drought all named alfalfa varieties except Ranger produced 6 tons of dry forage or more in a 3-cut management system, the last cut being made September 3. Some summer killing, presumably due to drought, was observed in the timothy trial. All orchardgrass varieties averaged over 5 tons of dry forage on a 3-cut system with the last cut made September 7. High variety was Pennlate with 5.9 tons per acre and low was the Canadian variety Rideau with just slightly over 5 tons per acre. Three nonflowering orchardgrasses compared favorably, or exceeded, commercial orchardgrass in yield.

WEST VIRGINIA

Title: DISEASES OF GRASSES

Leaders: Edward S. Elliott and K. L. Deahl

Data collected in the field indicated that increasing nitrogen applications on Kentucky bluegrass increased grass growth and the damage from Helminthosporium leafspot, but diseased tissue was increased at a slower rate, resulting in greater amounts of disease-free forage. These studies are being repeated in the greenhouse with more adequate control of the environment in an attempt to confirm data collected in the field.

A study is being made of a small area where considerable damage from Twist (caused by Dilophospora) is evident in orchardgrass. This area is of particular interest because no Twist has been found on other orchardgrass plantings in the region indicating this may be a center from which the disease might spread.

Title: THE PERFORMANCE OF SEVERAL ALFALFA VARIETIES GROWN
UNDER DIFFERENT CLIMATIC CONDITIONS, WITH EMPHASIS
ON THE INFLUENCE OF FALL CUTTING

Leader: Gerald A. Jung

The forage yields for 1964 (5th recurring year) were analyzed statistically. Significant sources of experimental variability from largest to smallest were: location, varieties, location x cutting management, and location x varieties. Of importance was the fact that the best variety (Vernal) with lenient fall cutting management produced an average (8 locations) yield of 4.5 tons per acre. First harvest yields were obtained in 1965 to evaluate the fall management treatments imposed in 1964. Statistical analysis of these data is not complete.

Cutting alfalfa stands in different stages of maturity on different dates throughout the fall showed that date of cutting was not important when the plants had considerable bloom (30%) on September 1. On the other hand, date of fall cutting affected yields considerably when the plants had little or no bloom on September 1.

Fall grazing studies continued to indicate that defoliation by means of cutting can produce vastly different results than defoliation by grazing. Cutting in late October has consistently been one of the best management treatments; grazing in late October appears to be one of the severest treatments. This is probably related to removal of well-developed crown buds by the grazing animals and not by mowing.

Title: BIOCHEMICAL STUDIES ON COLD RESISTANCE OF ALFALFA

Leader: Gerald A. Jung

Studies on the rate of respiration of very hardy and moderately hardy alfalfa varieties during the development of cold hardiness were completed and a manuscript prepared. Varietal differences were more numerous when respiration rate was the opposite for the dry whole tissue or dry leaves parameters than for the plant or stem parameters. Respiration rate of the hardier alfalfa varieties was affected more than the less hardy varieties by cutting in September or October compared to cutting in August. Respiration rates expressed with dry whole tissue or dry leaves parameters were higher for plants cut in September or October than for those cut in August, but the reverse was true when the respiration rates were expressed with the plant or stem parameters. The effect of temperature on respiration rate, over the range 0-20°C, was significantly modified by cutting management. Certain regression slopes for respiration and temperature were significantly altered by parameter. Low field temperatures appeared to have a temporary inhibitory effect on respiration rate.

Title: RATE AND TIME OF APPLICATION OF POTASSIUM FOR ALFALFA

Leaders: R. F. Keefer and P. R. Henderlong

In most instances, total yield of dry matter per acre for 5 years from 3 locations was highest where alfalfa was fertilized in the early spring. Although some variation occurred between treatments, greatest fluctuation in total yield from year to year undoubtedly was the result of environmental conditions. This was especially true at one location (Wardensville) where moisture has been limiting in the last few years.

Persistence of alfalfa was measured by visual observation (percent stand in 1965) and much variation was noticed between the plots at 2 locations. Potassium fertilization in the early part of the year at Morgantown seemed to maintain the alfalfa better. At Point Pleasant, however, just the reverse was true, i.e., late fall application was equal to or superior to earlier applications. This difference was probably caused by soil differences. No difference in stand was noticed at Wardensville.

Plant tissue analyses for 1964 showed that the early spring fertilization caused greatest uptake of potassium at all rates and all 3 locations.

Title: NUTRITION, SOIL, AND HERBAGE INTERRELATIONSHIPS IN
SYNDROME RESEMBLING HYPOMAGNESEMIA TETANY IN RUMINANTS

Leader: D. J. Horvath

Work has been done to compare the relative effectiveness of different Mg supplements when beef cattle are turned on to spring pasture. Supplements tested were (1) compressed blocks of ground corn cob, molasses, magnesium oxide and salt, (2) blocks made of mixtures of (a) magnesium oxide and molasses, 1:1, (b) magnesium oxide, salt and molasses, 2:1:3, (3) liquid molasses and magnesium oxide supplied in barrels. Effectiveness was measured by observational study of grazing cattle, changes in block weights on a daily basis, levels of serum magnesium. The liquid supplement was effective in maintaining serum magnesium levels, but study of this treatment has been discontinued because of the inconvenience of handling. Consumption of blocks was found to vary considerably with their position in the pasture. Serum magnesium analysis is in progress.

A study is being run on the effect of different levels of nitrogen fertilization on the levels of blood magnesium (and other minerals) in sheep grazing orchardgrass at different stages of growth.

Title: PRELIMINARY INVESTIGATION - FEEDING AND
MANAGEMENT OF DAIRY CATTLE

Leader: Roy Thomas

Preliminary trials with dairy cows indicated that hays fed individually or combined had different effects on intake and on milk production. Intake decreased in the order (1) orchardgrass, (2) legume hay, (3) orchardgrass + legume, while for milk production the order was (1) legume, (2) orchardgrass + legume, (3) orchardgrass. Growing heifers fed corn and legume-grass silage gained body weight at a faster rate than heifers fed either silage singly. Further trials are being run to evaluate these silages for growth and milk production in dairy animals.

Title: THE EFFECTIVE USE OF BLUEGRASS-WHITE CLOVER PASTURES

Leaders: G. C. Anderson, P. R. Henderlong, C. E. Toben, and
L. P. Stevens

The experimental site has been prepared and seedings were established during the fall of 1965. The first grazing trials will be initiated in the spring of 1966. The study essentially involves an attempt to determine the production potential of bluegrass-white clover associations as influenced by slope exposure or orientation. The hillside or mountain pastures (in bluegrass-white clover) will be supplemented by pure grass species (bluegrass, orchardgrass and tall fescue) in bottomland (or tillable land) as a means of maximizing total production of West Virginia pastures. The area in the pure grass swards will either be harvested for hay or used for grazing, depending upon the production of the hillside swards.

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